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STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES

CALIFORNIA JOURNAL OF MINES AND GEOLOGY

Volume 51, Number 1
JANUARY 1955

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Vol. 51 JANUARY 1955 No. 1

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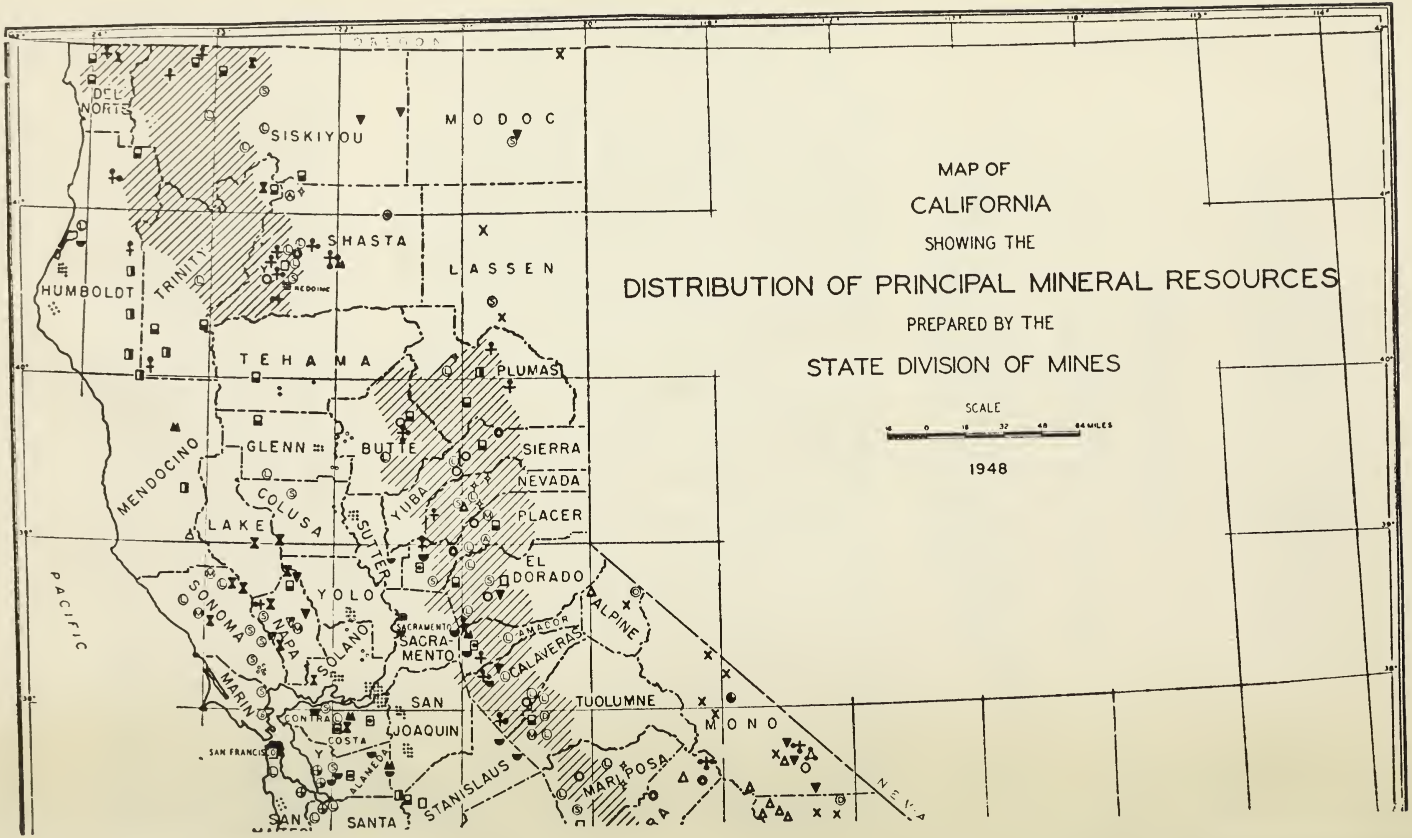

MAP OF
CALIFORNIA
SHOWING THE
DISTRIBUTION OF PRINCIPAL MINERAL RESOURCES
PREPARED BY THE
STATE DIVISION OF MINES

SCALE

1948

OREGON
DEL NORTE
SISKIYOU
MODOC
HUMBOLDT
TRINITY
SHASTA
LASSEN
REDDING
TEHAMA
PLUMAS
MENDOCINO
GLENN
BUTTE
SIERRA
NEVADA
COLUSA
YUBA
PLACER
LAKE
SUTTER
EL DORADO
ALPINE
SONOMA
YOLO
NAPA
SOLANO
SACRAMENTO
SACRA-MENTO
AMADOR
CALAVERAS
MARIN
SAN JOAQUIN
TUOLUMNE
MONO
CONTRA COSTA
SAN FRANCISCO
ALAMEDA
STANISLAUS
MARIPOSA
SAN
SANTA
PACIFIC
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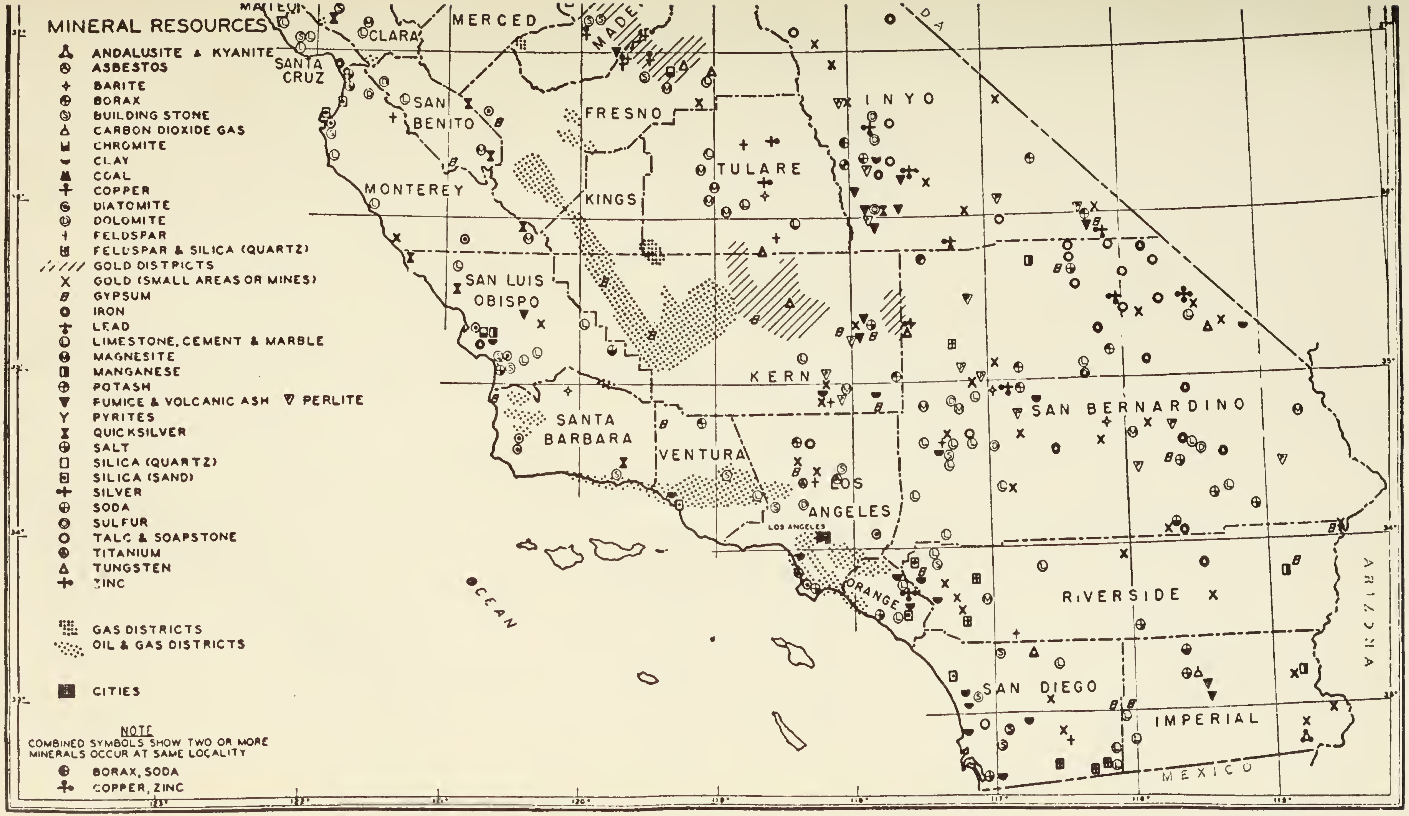
MINERAL RESOURCES
ANDALUSITE & KYANITE
ASBESTOS
BARITE
BORAX
BUILDING STONE
CARBON DIOXIDE GAS
CHROMITE
CLAY
COAL
COPPER
DIATOMITE
DOLOMITE
FELDSPAR
FELDSPAR & SILICA (QUARTZ)
GOLD DISTRICTS
GOLD (SMALL AREAS OR MINES)
GYPSUM
IRON
LEAD
LIMESTONE, CEMENT & MARBLE
MAGNESITE
MANGANESE
POTASH
PUMICE & VOLCANIC ASH
PERLITE
PYRITES
QUICKSILVER
SALT
SILICA (QUARTZ)
SILICA (SAND)
SILVER
SODA
SULFUR
TALC & SOAPSTONE
TITANIUM
TUNGSTEN
ZINC
GAS DISTRICTS
OIL & GAS DISTRICTS
CITIES
NOTE
COMBINED SYMBOLS SHOW TWO OR MORE MINERALS OCCUR AT SAME LOCALITY
BORAX, SODA
COPPER, ZINC
MATEO
SANTA CRUZ
CLARA
MERCED
MADERA
SAN BENITO
FRESNO
MONTEREY
KINGS
TULARE
INYO
SAN LUIS OBISPO
KERN
SANTA BARBARA
VENTURA
LOS ANGELES
ORANGE
SAN BERNARDINO
RIVERSIDE
SAN DIEGO
IMPERIAL
ARIZONA
MEXICO
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Plate 1. Geologic map of San Joaquin County, California, showing mines and mineral deposits In pocket

MINERAL USE IN COATED WELDING ELECTRODES

By Richard M. Stewart *

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ABSTRACT

Several mineral commodities are used in the manufacture of coatings for welding electrodes. Most coating ingredients, such as rutile and limestone, are multi-purpose but are often described as serving only one of the following coating functions: 1) arc shielding, 2) arc stabilization, 3) weld deoxidation and alloying, and 4) form slags and fluxes. The minerals are used in relatively small quantities and are handled through distributors. Some minerals not now in use for coatings, may be so utilized in the near future. The importance of the industry is far greater than is indicated by the small quantities of minerals.

INTRODUCTION

Much of the physical aspect of our society has been made possible through the process of arc welding. The joining of heavy plates and large girders once was entirely dependent upon the use of a large number of rivets or bolts. Riveted seams of tanks and pressure vessels had to be calked, a laborious and not always effective procedure. Arc welding revolutionized much of engineering practice and many processes of industrial construction, and the modern achievements of arc welding stem largely from the development of coatings for welding electrodes.

The idea of arc welding was conceived as early as 1890, and in 1905 a process for covering the bare electrode wire with a coating was granted a patent in Germany. Even though the coated electrode thus had its origin in Europe, extensive research and development has led to American-designed electrodes having a wider range of operating characteristics.

The welding electrode industry is represented by six firms in the Los Angeles area (table 2). These manufacture coated and uncoated welding electrodes for conventional welding, for welding stainless steels and for hard facing machinery parts subjected to heavy wear. During

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* Associate mining geologist, California Division of Mines. Manuscript submitted for publication March 1954.

*Table 1. Functions of some electrode coating materials.**

Material	Arc shielding	Arc stabilization	Oxidizing agents	Slag and flux	Reducing agents	Coating strength, slip, etc.	Alloy weld metal	Binder
Asbestos (tremolite or chrysotile)		S		P		P		
Brucite		S		P				
Clay (kaolin and bentonite)				P				
Cryolite				P				
Diatomite				P		P		
Feldspar (potash and soda)		S		P				
Fluorspar		S		P				
Graphite (natural and manufactured)	S				P	P	P	
Iron oxides (hematite and magnetite)		S	P	P		S		
Lepidolite		P		S				
Limestone (and dolomite)	P	S	S	S				
Manganese oxides (and rhodochrosite)			P	P				
Mica		S		P		P		
Silica (flour)				P				
Talc		S		P				
Titanium minerals (principally rutile and titanium dioxide, also brookite and ilmenite)		P		S				
Wollastonite				P				
Cellulose	P				S	S		
Potassium silicate (liquid)		P		P				P
Sodium silicate (liquid)		S		P				P
Ferro alloys				P			P	

P—Primary function
S—Secondary function

* Note: Not all of these materials are used in the Los Angeles area.

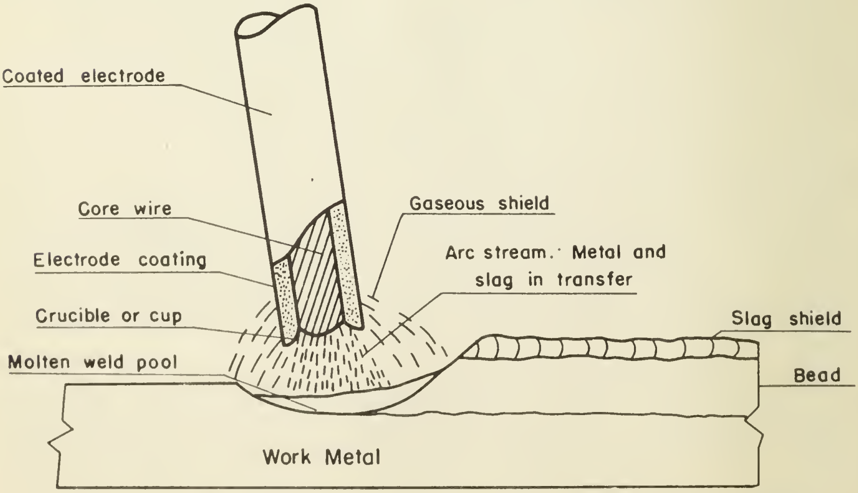
Coated electrode
Core wire
Electrode coating
Crucible or cup
Molten weld pool
Gaseous shield
Arc stream. Metal and slag in transfer
Slag shield
Bead
Work Metal

FIGURE 1. Diagrammatic sketch of coated electrode during welding process.

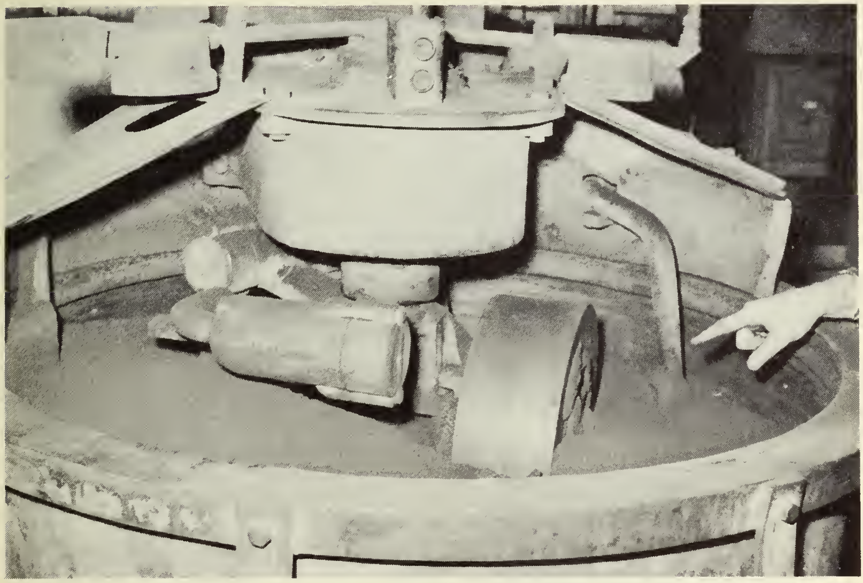

FIGURE 2. Muller used for mixing and grinding materials for electrode coatings. *Photo courtesy Stoody Company.*

the early part of 1953, a survey was made of the industry as represented by these firms to determine what minerals were used, their amounts and specifications. Firms outside the Los Angeles area were contacted to gain more basic information than was available in the sparse coverage of the subject by the technical literature.

The following discussion is presented as a broad explanation of the manner in which an electrode functions and of the part played by the mineral coating ingredients. No attempt is made to explain the effect of the coatings on such complex problems as globular versus spray

Table 2. Manufacturers of coated welding electrodes in the Los Angeles area (1953).

Firm	Type of electrode	Method of coating
1. Johnston Stainless Welding Rods, Inc., 1845 East 57th Street, Los Angeles, California	stainless	extrusion
2. Mir-O-Col Alloy Co. Inc., 312 North Avenue 21, Los Angeles, California	hard facing	extrusion and dipping
3. Pacific Welding Alloys Mfg. Co., 310 North Avenue 21, Los Angeles, California	stainless and fusion	extrusion and dipping
4. Rankin Manufacturing Company, 3072 West Pico Boulevard, Los Angeles, California	hard facing	dipping
5. Stoody Company, 11928 East Slauson Avenue, Whittier, California	hard facing	extrusion and dipping
6. Victor Equipment Company, 11440 South Alameda Street, Los Angeles, California	hard facing	dipping

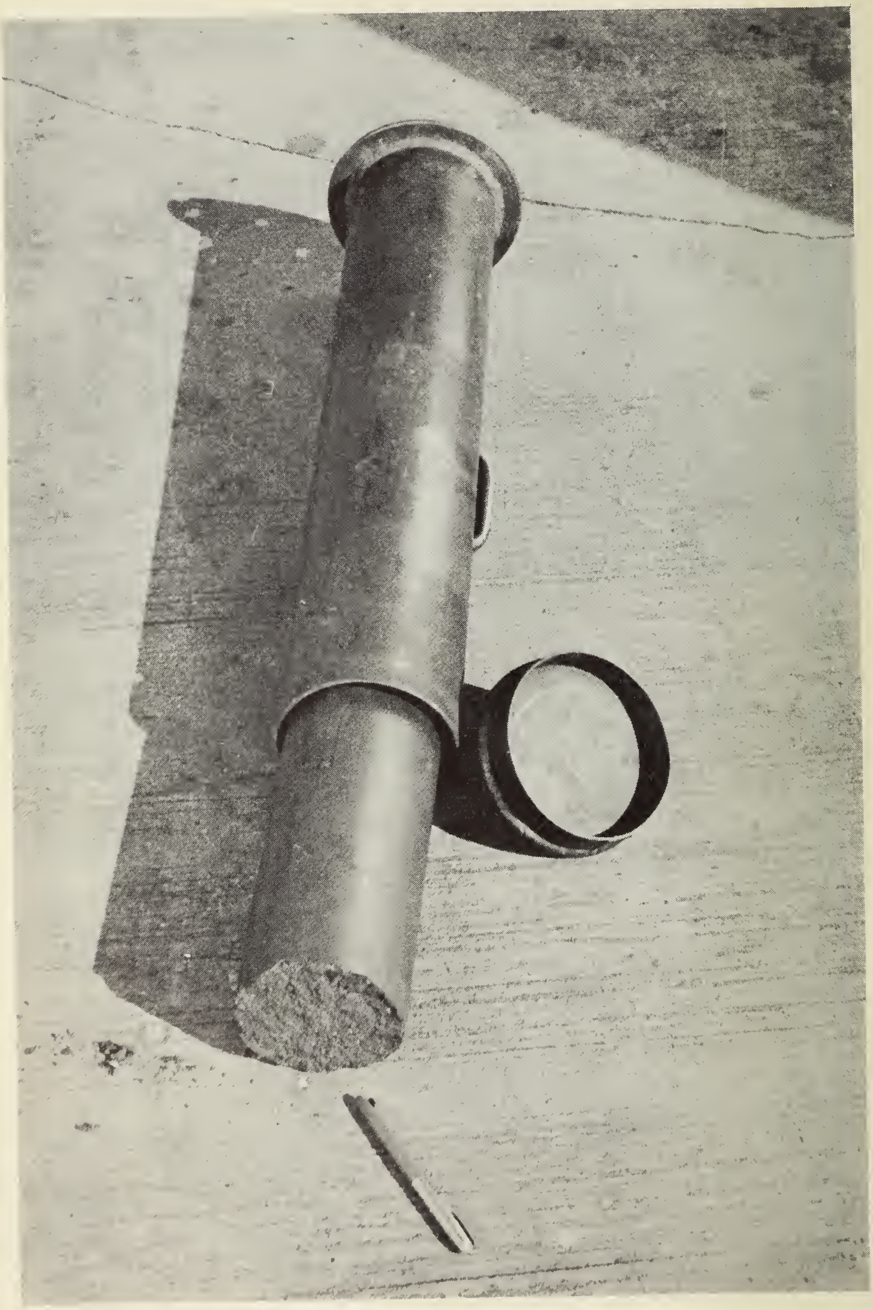

FIGURE 3. Compressed "slug" or cylinder of coating materials ready for hydraulic press. *Photo courtesy Stoody Company.*

type of metal transfer, oxygen ratios, deposition rates, arc energy and depth of penetration, A. C. or D. C. electrode operation and many others.

An electrode coating consists of a combination of minerals, ferroalloys, chemicals and sometimes cellulose, mixed with a binder, commonly sodium silicate, and applied to a core wire. A great variety of materials have been used in many combinations.

Minerals commonly constitute the major portion of a coating. They provide a wide range in composition and physical characteristics which may not be readily available in manufactured chemical materials. It would not be feasible, even if possible, to manufacture a silicate having the slag-forming characteristics and physical nature of a mineral such as asbestos. Nor could chemically prepared calcium carbonate compete with limestone for use in coatings as a source of carbon dioxide gas. Minerals can be ground to meet particle size requirements, and some have platy or fibrous structure which improve the strength or slip characteristics of the coating.

COATING CLASSIFICATION

Coatings can be classified according to their contents or the manner in which they function to facilitate and protect the weld. Thus the coating types classified as to content are mineral and cellulosic; the coating types classified as to the method of weld protection are gas-producing and slag-producing. The relationship of these types is indicated below:

Type of coating	*Slag-producing*	*Gas-producing*
Mineral	primarily	secondarily
Cellulosic	secondarily	primarily

Mineral coatings, which originally utilized materials normally used in metallurgical slags, may include some cellulose but always less than 30 percent. They may be further divided into types such as lime base, rutile or ''titania'' base and iron oxide base, depending upon the major constituent. Mineral coatings are primarily slag-producing, but because it is necessary to protect the weld metal during its transfer in the arc stream, most coatings contain gas-forming ingredients to form a protective shield around the arc stream.

Cellulosic coatings contain more than 30 percent pure cellulose; minerals may or may not be present and sodium silicate is the common binding agent. The organic matter in these coatings breaks down in the arc to form a gaseous envelope covering the arc stream and the weld.

COATING FUNCTIONS

The many functions of the electrode coating are summarized as follows:

1. Shield the arc stream and the weld-metal deposit against atmospheric contamination.
2. Provide an ionized path to maintain the arc and to control arc energy.
3. Provide ingredients to deoxidize the weld deposit and to introduce alloying elements into the weld.
4. Form slag to flux the weld deposit to give additional protection from atmospheric contamination and to control weld appearance and contour.

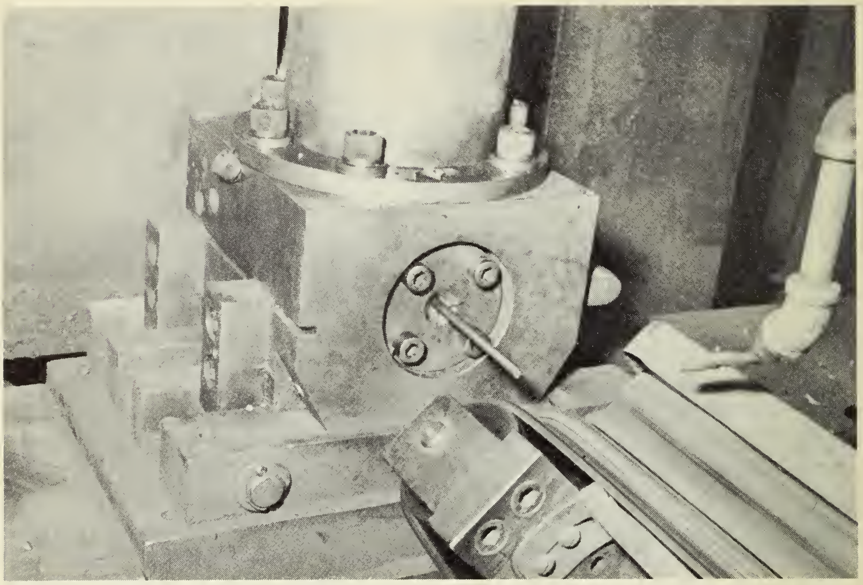

FIGURE 4. Discharge end of hydraulic press. A coated electrode extends out from the adjustable extrusion head. Coating material is forced into the extrusion chamber from hydraulic cylinder above. *Photo courtesy Stoody Company.*

COATING INGREDIENTS AS RELATED TO FUNCTION

Coating ingredients are commonly referred to as serving only one of the above functions, but most ingredients are multi-purpose. In the complex chemical and thermal reactions taking place during the welding operations, minerals commonly supply qualities quite remote from those for which they primarily are present. Also because of inter-reaction of coating ingredients, a mineral primarily serving a specific function in one formulation might not be efficiently utilized for the same function in another formulation.

Coatings may contain only a few ingredients or they may be quite complex, containing as many as 20 materials in a single formulation. In those containing many materials, effects are obtained by a combination of ingredients rather than by adding one particular ingredient

Table 3. Estimated consumption of some mineral commodities in coated electrode manufacture in the Los Angeles area (1953).

Commodity	Pounds per month
Rutile	10,800
Iron oxide (magnetite)	5,000
Limestone	4,000
Fluorspar	3,500
Titanium dioxide (manufactured, technical and pigment grades, total)	3,500
Feldspar	2,000
Talc	1,600
Silica flour	1,000
Brucite	1,000
Rhodochrosite	1,000

to obtain a definite effect. Exact formulations in the manufacture of electrode coatings are usually confidential.

The first of the electrode coating functions, arc shielding, has been briefly mentioned above in the discussion of coating classifications. Gas for arc shielding in the mineral coatings is usually produced by limestone which dissociates into calcium oxide and carbon dioxide gas. This gas provides a shield surrounding the arc and to some extent the weld. The calcium oxide combines with other materials and enters the slag. Limestone for this purpose is obtained from southern California sources through local mineral distributors. It is fairly coarse, ranging from 60 to 200 mesh.

Arc shielding is also accomplished to a limited degree by the formation of the ''crucible'' or ''cup'' at the end of the electrode (see fig. 1). Because heat is concentrated at the core wire, the electrode coating melts more slowly and tends to form a cylindrical shell around the core. The core metal is thus protected from the atmosphere as it first melts and is transferred in the arc along with slag from the coating to the point of deposition. In some electrode use the coating remains in contact with the work metal; electrode metal is then transferred from the ''cup'' to the point of deposition completely shielded from the atmosphere.

Minerals that break down in the arc to form an ionized path are called arc stabilizers. The stabilizers most commonly used are rutile and manufactured titanium dioxide. Rutile specifications require a minimum of 92 percent TiO_2, and about 3 size ranges, minus 50- plus 100-mesh, minus 200-mesh and minus 325-mesh. Rutile is obtained through local mineral distributors from sources in Florida or Australia. Technical and pigment grades of titanium dioxide are used. Technical grade contains about 99.6 percent TiO_2 but has little pigment value; pigment grade contains from 98 to 99 percent TiO_2.

Ferro-alloys constitute a substantial part of most coatings. They deoxidize the weld metal and give it special qualities. It is more satisfactory and economical to enrich the weld metal by using a low-carbon steel core wire and a coating containing ferro-alloys than to use a high-alloy core wire. Electrodes for hard-facing purposes (see fig. 1) are frequently made, however, by enclosing a material such as tungsten carbide in a mild-steel tube which then can be coated if and as desired. Certain special-alloy electrodes are cast in rod shape and coated by the dipping process described later in this report. Most of these metal products are furnished to the manufacturer in the finished state. Tungsten carbide however, is usually produced by the manufacturers of hard facing materials. It differs from the sintered carbides used for tools, in that it is a eutectic composition of WC and W_2C containing approximately 4.2 percent carbon.

Graphite, a multi-purpose ingredient, provides carbon to compensate for the carbon lost from the steel in the heat of the arc, thus keeping certain qualities in the steel or adding to them. Graphite is also important during the manufacturing process because it provides slip characteristics to the coating; it is a weak source of CO_2 gas for arc shielding and acts as a reducing flux. Natural graphite must contain a minimum of 85 percent carbon and usually is ground to minus 200-mesh. Natural graphite from Mexico is used in the Los Angeles area and is obtained from local distributors. Artificial graphite also is used.

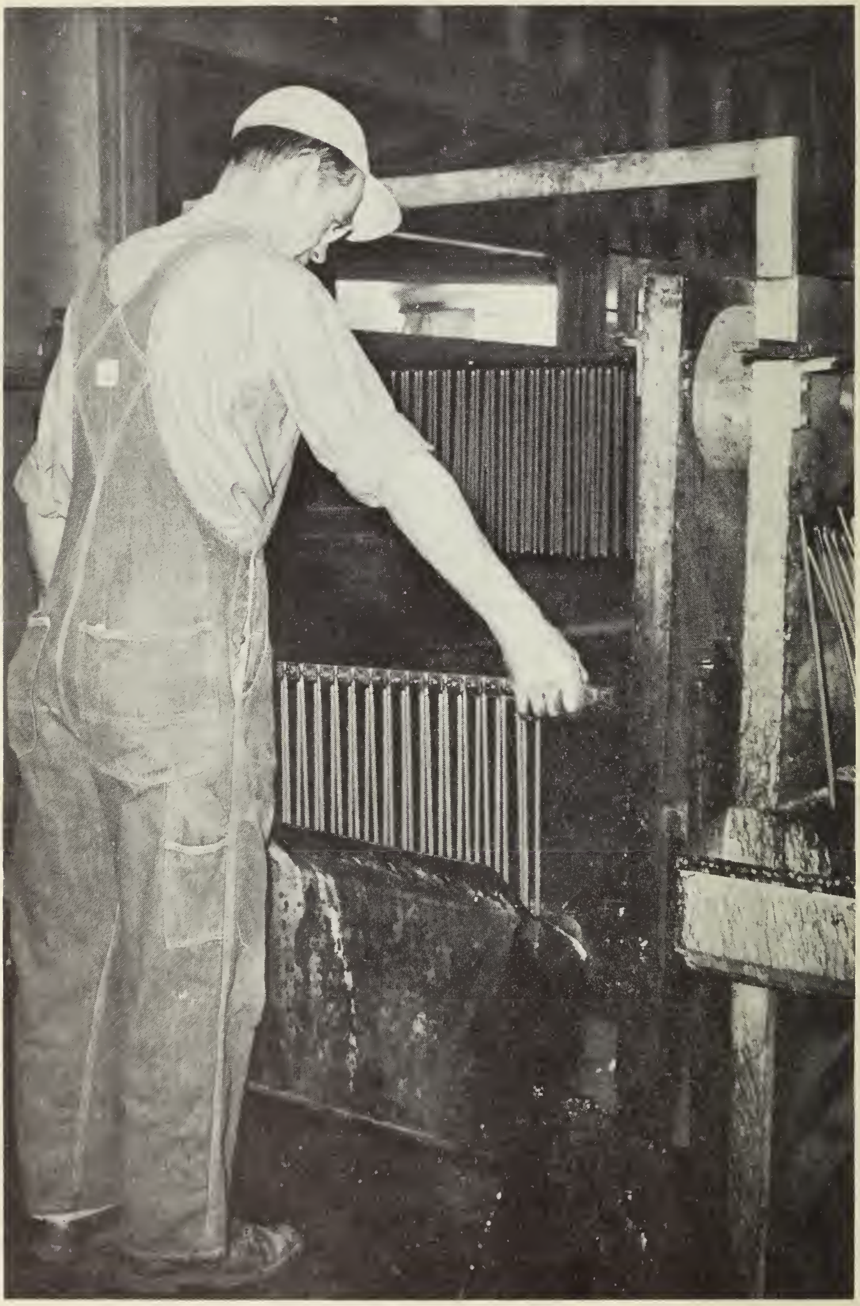

FIGURE 5. Electrode being coated by dipping process. *Photo courtesy Stoody Company.*

One of the more important considerations in coating formulation is the volume and nature of the slag formed during welding. Much of the slag results from the decomposition of or reaction between coating ingredients that are present for other specific purposes. This source however, cannot always be relied upon to make sufficient slag volume or to make a slag having a suitable melting point, surface tension, viscosity, or the necessary fluxing characteristics. Ingredients must be present in the coating to insure a slag having the desired properties but must be selected with regard to their effect on the other functions of the coating.

Slags and fluxes are generally considered together and a slag that protects the molten metal by merely floating on its surface is seldom used. Most slags are fluxing slags in that they contain ingredients that not only act to protect the metal from oxidation, but also dispose of any oxides formed.

Fluxes can dispose of oxides by any of several methods. The flux may mix with a refractory oxide to form a material having a lower melting point and viscosity. Thus silica added to aluminum oxide, alumina, forms a compound having a lower melting point than the alumina. The flux may also dissolve the oxide. Chloride or fluoride salts will dissolve an oxide such as alumina. Also, chromic oxide, formed in welding stainless steel, is removed by adding fluorspar to the coating. A third fluxing method reduces the undesirable oxide to form a less refractory oxide or one that can be removed by one of the other methods.

The physical properties of the slag, especially its melting point and viscosity, determines the suitability of the electrode for the several welding positions and controls the contour and appearance of the weld bead. If the electrode is to be used for overhead welding, a relatively small volume of slag is desired, and it must not be so fluid as to drip. For most types of welding, the slag should have a surface tension low enough to ''wet'' the work metal and prevent entrapment in channels and to influence the weld contour. A fillet weld having a concave cross-section is desired and is obtained by using a ''wet'' slag.

As shown in table 1, slagging or fluxing is the primary or secondary function of the majority of the coating materials listed. Of the primary slagging or fluxing materials that are most used locally, only talc is obtained from California sources. Feldspar and silica are obtained through local distributors from Kingman, Arizona. The feldspar is finely ground, all minus 200-mesh. Fluorspar is also obtained from distributors and a minimum CaF_2 content of 60 percent is usually specified.

In the production of any mineral for coating use, the question of impurities and particle size must be considered. Elements that are considered injurious to the weld metal are those normally not acceptable in any ferrous metallurgical process and include sulphur, phosphorus, lead, tin, and antimony. Proportions of these must be held to a minimum consistent with reasonable cost.

During electrode operation the particle size of the coating ingredients plays an important role in determining alloy and metal transfer and deposition efficiency, arc action, slag characteristics and weld metal deoxidation. Particle size also affects such production problems as extrudability, green strength and drying characteristics. Fine particles

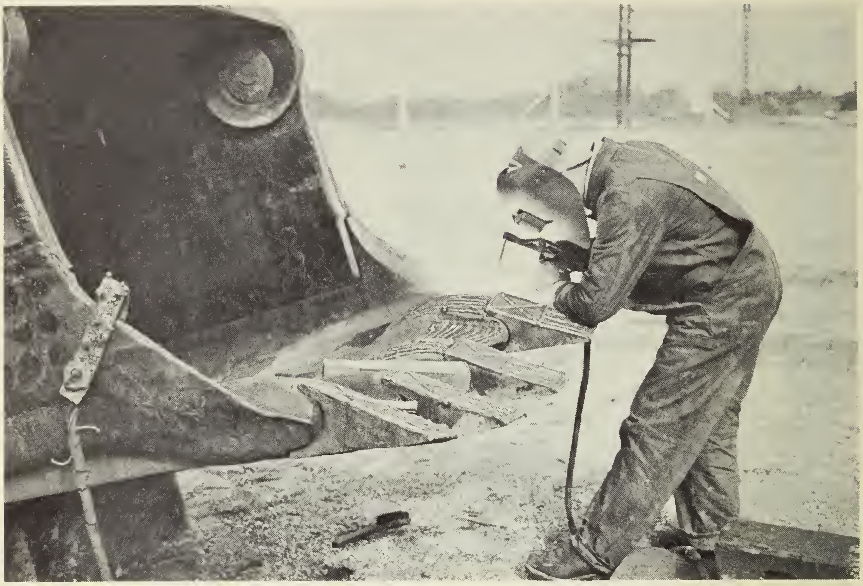

FIGURE 6. Application of hard-facing material from coated welding electrode. *Photo courtesy the Stoody Company.*

tend to favor smoother arc action, but coarser particles favor such factors as resistance to drying cracks during manufacture and alloy transfer efficiency. Increasing the size of silica particles seems to produce an easily removed slag and one giving better weld bead contour. A uniform particle size is desirable.

MANUFACTURING

The manufacturing process involves mixing the desired ingredients and adding enough binding agent, usually liquid sodium silicate, to give the proper consistency for either the extrusion process or the dipping process. The extrusion process requires a stiff mixture with relatively little moisture; dipping requires a liquid mixture.

In the extrusion process, the coating mixture is formed into a solid cylinder or ''slug'' and then placed into a specially designed hydraulic press. Electrode wire is then fed into a chamber in the press, and the coating mixture is forced under high pressure into this same chamber. The electrode wire is forced out of the chamber through a die set to leave the desired thickness of coating on the wire. The coating must be nearly concentric on the wire, and the die can be adjusted to insure this concentricity. The American Welding Society has set up certain specifications for coatings which provide, among other things, that the coating must be concentric within specified limits—usually 3 to 5 percent.

The dipping process merely entails dipping the rod one or more times into the liquid coating mixture. Cast rods, usually of high-alloy material, must be coated in this manner. Because cast rods are hard and ordinarily not ductile, there is a high probability of breakage in the coating chamber or dies. Moreover most cast rods become bowed or warped when removed from the mold thus precluding any possibility of extrusion.

The amount of coating applied to the electrode is determined in part by the intended usage; especially considered are the positions in which the electrode is to be operated. The weight of the coating may range from 5 to 25 percent of the weight of the core wire.

After being coated by either of the two processes, the rods are dried in air or in moderately heated ovens and then baked at temperatures ranging from 300 to 500° F. It is essential that the coating remain unvitrified, for the ingredients must retain their identity in order to perform their intended functions.

CONCLUSIONS

The study of the minerals utilized by the manufacturers of coated electrodes in the Los Angeles area, has led to several conclusions.

1. Relatively small quantities of the several minerals are used. The estimated aggregate monthly consumption of some of these minerals is listed in table 3.
2. These minerals are obtained, almost without exception, from local mineral distributors.
3. The possibility exists that several minerals not now in use locally may be utilized in the future. Because of the small quantities used by individual plants, these minerals would, no doubt, have to be distributed through the local distributors. Some minerals that could possibly be used and that are found in southern California are lepidolite, rhodonite, titaniferous magnetite (an ilmenite-magnetite intergrowth) and wollastonite.
4. The importance of the industry is far greater than would be indicated by the quantity of minerals used.

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MINES AND MINERAL RESOURCES OF SAN JOAQUIN COUNTY, CALIFORNIA

By William B. Clark *

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* Assistant Mining Geologist, California Division of Mines. Manuscript submitted for publication January 1954.

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ABSTRACT

San Joaquin County lies largely in the Great Valley, although the southwestern portion is in the Coast Range and the extreme eastern portion is in low foothills of the Sierra Nevada. The Great Valley is an alluvial plain underlain with sediments ranging from Upper Cretaceous to Recent in age. Rocks of the Coast Range in San Joaquin County are chiefly sedimentary, ranging from Upper Jurassic to Quaternary in age. The Sierran foothills contain fragmental volcanic rocks of Tertiary age and a considerable amount of overlying detrital material.

From 1885 to 1951, recorded mineral production for the county totaled $42,969,646. In 1951, mineral production was $3,027,741, ranking it 23rd of the 58 counties in value of production. This production included sand and gravel, natural gas, clay and clay products, gold, platinum, silver, and stone. Manganese ore has been produced continuously since 1951.

Common brick, sewer pipe, drain tile, and dinnerware are produced at plants in the Stockton area. Alluvial clays of Recent age are quarried from pits at two of these plants, but it is necessary to import substantial quantities of raw clay.

Until 1951, gold and minor amounts of silver and platinum were produced from placer deposits in eastern San Joaquin County. The largest producer was the Gold Hill Company which operated two floating connected bucket dredges on the Mokelumne River near Clements.

Manganese ore has been produced intermittently from chert of the Franciscan formation in the Ladd area since 1867. The Ladd mine is now producing 100 tons of manganese ore per day which is concentrated in a plant south of Tracy for use in the battery industry.

Natural gas is produced from Eocene and Cretaceous formations in 7 gas fields in western and northern San Joaquin County. Except for the McDonald Island gas field, all have small estimated reserves. Natural gas has been produced in the county since 1858, when the famous Court House well in Stockton was completed.

Sand and gravel, the most important mineral commodity of the county, occurs in alluvial fans in the southwestern portion and in and near stream channels in the eastern portion of San Joaquin County. Two modern plants south of Tracy and one near Clements are the largest producers.

In the past, minor amounts of limestone and glass sand were produced from Corral Hollow. Large reserves of peat underlie the delta region of northeastern San Joaquin County.

Substantial amounts of sand and cement are used in concrete pipe manufacturing plants and sand and expanded shale are used in a lightweight building block plant near Stockton. From 1942 to 1944 and 1951 to 1953, magnesium metal was produced in a plant at Manteca. Much high-calcium limestone and some processed diatomite is used in two beet sugar refineries in the county. Diatomite is also used as a filter

aid in many wineries near Lodi. Other mineral commodities used in varying amounts in the county are silica sand, bentonite, sulfur, and coal.

INTRODUCTION

San Joaquin County, lying chiefly within the Great Valley of California, in the central part of the state, is bounded on the north by Sacramento, on the east by Amador and Calaveras, on the south by Stanislaus, and on the west by Alameda and Contra Costa Counties.

The county was named for the San Joaquin River, which, in turn, had been named in honor of St. Joachim by Gabriel Moraga in 1813. The county was first visited by white men in the period 1805-11; French Camp, occupied by French-Canadian hunters in 1830, was the first white settlement in the county. In 1850, by act of the young California legislature, San Joaquin County was created as one of the original counties of California.

Geography. San Joaquin County has an area of 1410 square miles. Elevations range from sea level to 3,618 feet at Mount Boardman, located in the southwest corner near the Alameda County line. The Mokelumne and Calaveras Rivers flow into the county from the east; Dry Creek flows along the northern border, and the Stanislaus River flows along the southern border. All of these streams empty into the San Joaquin River which flows northwest across the county.

Stockton, laid out by Captain Weber in 1847, has grown from a population of 1000 in 1849 to 70,853 in 1950. It is the county seat and the largest city. An important manufacturing and transportation center, Stockton is also an important seaport, as a deep-water ship channel connects it with the lower Sacramento River and San Francisco Bay. Other cities are: Lodi, population 13,798, an important wine and agriculture center; Tracy, population 8,410, a transportation and manufacturing center; and Manteca, a meat packing and dairy center. Towns include Escalon, Ripon, Thornton, Lockeford, Woodbridge, Clements, and Lathrop.

Three transcontinental railroads, the Southern Pacific, Western Pacific, and Santa Fe, and three shortline railroads serve San Joaquin County. U.S. Highway 99 runs north through the county; U.S. Highway 50 runs east from Tracy to Stockton and thence north in conjunction with U.S. Highway 99. The county is also served by State Highways 4, 8, 12, 33, 88, and 120, and numerous roads.

The two aqueducts that supply the San Francisco Bay area with water cross the county. The Mokelumne aqueduct of the East Bay Municipal Utility District runs from the northeast corner of the county to a point east of Stockton and thence west across Roberts and Woodward Islands. The Hetch Hetchy aqueduct of the San Francisco Water Department crosses the southwest portion of the county from Vernalis through the Corral Hollow area. Pipelines connecting the oil refineries in the Richmond-Martinez area with oil fields in the southwestern San Joaquin Valley run along the western portion of the county, as do natural gas trunk lines. The Delta-Mendota Canal, the major link of the Central Valley Project, extends along the western margin of the Great Valley in San Joaquin County.

Industries. Agriculture and manufacturing industries associated with agriculture are the chief sources of income in the county. Agricultural production in 1952 totaled $156,438,765. Principal products were vegetable crops, fruit and nuts, field crops, livestock, and dairy products. Manufacturing industries include food processing and packaging, lumber and wood products, farm machinery, and building materials. The transportation industry is an important source of income in San Joaquin County. Iron ore, which is mined in Nevada, is shipped to Japan from the Port of Stockton.

GEOLOGY

San Joaquin County extends into three of the eleven geomorphic provinces of California. They are the Great Valley, the Sierra Nevada, and the Coast Ranges, each with certain distinct major geologic features. The result, so far as the geology of San Joaquin County is concerned, is the division of the county into three geologic units: the west side, reflecting the geologic processes that shaped the Coast Ranges, the east side, exhibiting structural features and rocks typical of the Sierra Nevada, and the central part, lying in the Great Valley, a nearly flat-lying, alluviated area that separates the two mountainous units. Of the rocks exposed throughout the county, only those of Upper Jurassic to Recent time intervals are represented.

Structural features visible in the eastern and western portions of the county differ considerably. In the western part, the exposed late Tertiary rocks are highly folded and faulted, a reflection of the late Tertiary and Quaternary orogenic processes that so greatly affected the Coast Ranges. On the eastern side, the exposed rocks, also Tertiary, are nearly flat-lying and undeformed, showing little evidence of orogenic activity in the late Tertiary and Quaternary times other than a slight westward tilting in the extreme eastern portion of the county. Underlying the eastern Tertiary rocks, however, is a series of intensively folded, faulted and metamorphosed rocks that reflect the Nevadan orogeny of the Sierra in late Jurassic time.

Economic mineral deposits in San Joaquin County occur in rocks ranging from Upper Jurassic to Recent in age. Manganese ore is found in chert of the Upper Jurassic(?) Franciscan formation in the Coast Ranges while natural gas occurs in Upper Cretaceous and Eocene sediments beneath the floor of the Great Valley. Sand and gravel, brick clay, and gold occur, chiefly in Recent alluvium in and near stream channels.

West Side

The southwest portion of San Joaquin County lies in the central Coast Range, a series of northwest-trending mountains composed of late Mesozoic sedimentary and metamorphic rocks, Cenozoic sediments, and associated intrusive and volcanic rocks.

Rock Formations

Franciscan Formation (Upper Jurassic ?). The oldest rocks found in western San Joaquin County are those of the Franciscan formation which makes up the bedrock of the central portion of the Coast Ranges. This formation is a thick assemblage of sedimentary, volcanic, igneous, and metamorphic rocks, with sedimentary rocks constituting the bulk of the formation (Huey, 1948, p. 15). The sedimentary rocks consist of bluish to greenish-gray arkosic sandstone, dark shale, white, gray, and red chert, and minor amounts of conglomerate; the remaining units include small amounts of diabase, greenish basalt, serpentinized gabbro, peridotite, and blue glaucophane schist.

On the basis of meager fossil evidence, the Franciscan formation has been placed as Upper Jurassic in age (Huey, 1948, p. 23). Nearly all of the contacts with the overlying Cretaceous formations are fault contacts.

Panoche Formation (Upper Cretaceous). The Panoche formation consists of extensive beds of sandstone and shale with minor amounts of conglomerate. The sandstone beds are gray to buff in color, massive to well-bedded, and, in places contain hard, dark red and brown concretions cemented with iron oxide. The shale is thinly bedded, blue-gray to brown in color, and argillaceous to silty. A few marine fossils found in the Panoche formation in the Corral Hollow area place it as Upper Cretaceous in age (Huey, 1948, p. 28).

Moreno Formation (Upper Cretaceous). The Moreno formation conformably overlies the Panoche in the Corral Hollow area (Huey, 1948, p. 33). It consists chiefly of dark gray to brown or purplish organic shale, but minor amounts of sandstone are found. Although most of the shale is argillaceous, some of it is sandy. Fossils, including *Radiolaria, Foraminifera,* and diatoms, together with some carbonaceous matter, have been discovered.

Tejon Formation (Eocene). The Tejon formation crops out in the area between Hospital and Corral Hollow Canyons. In San Joaquin County, the formation consists of fine-grained clayey, micaceous, gray sandstone with interstratified beds of gritty clay, clay shale, dark carbonaceous shale, and some small lenses of lignite. The beds are marine and estuarine in origin (Anderson and Park, 1915, p. 67). The Tejon rests unconformably upon the Upper Cretaceous Moreno formation.

Tesla Formation (Middle Eocene). Originally mapped as the Tejon formation by Anderson and Pack (1915, p. 72), the name Tesla formation was proposed by Huey (1948, p. 33) for a group of brackish water and marine sedimentary rocks exposed in Corral Hollow.

The formation is composed of white quartz sandstone, buff sandstone, dark carbonaceous shale, lignite seams, and white to blue clay. The white quartz sandstone contains a high percentage of silica. The Tesla sandstone and clay beds are lithologically similar to those of the Ione formation in the Sierra Nevada foothills.

Brackish-water deposits predominate in the lower part of the formation while the upper part is characterized by marine deposits (Huey, 1948, p. 34). Fossil assemblages place the Tesla formation in the middle part of the Eocene epoch.

Cierbo Formation (Upper Miocene). The Cierbo formation, the middle member of the San Pablo group, crops out in several areas north of Corral Hollow. Exposures in San Joaquin County are few and poor. The formation consists of beds of coarse white quartzose sandstone, yellow and buff sandstone, and conglomerate, though tuff and brown shale beds are also present. Numerous fossils indicate the Cierbo formation is upper Miocene in age (Huey, 1948, p. 41).

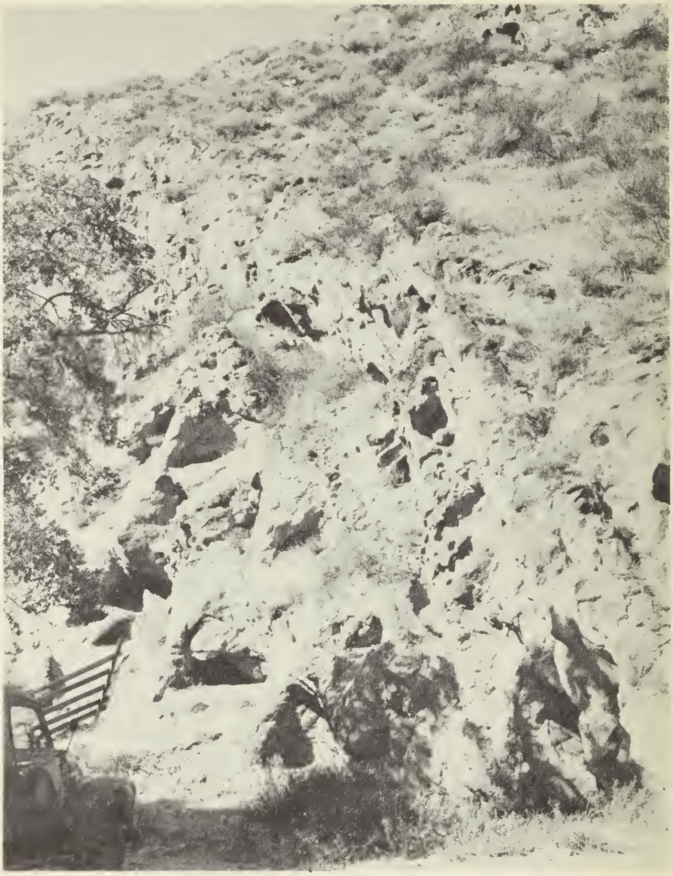

FIGURE 1. Outcrop of Neroly sandstone in Corral Hollow Canyon.

Neroly Formation (Mio-Pliocene). The upper unit of the San Pablo group, the Neroly formation, occurs in extensive beds east of Altamont Pass and in the Corral Hollow Canyon. In these exposures the Neroly can be divided into two parts: a lower part consisting of coarse blue sandstone, some conglomerate, and tuffaceous clay shale; an upper part consisting of clay with minor amounts of brown sandstone, gravel, and some blue sandstone. The distinctive blue color of the sandstone, which is the most characteristic feature of this formation, is caused by an opaline coating on the grains (Huey, 1948, p. 43).

Tulare Formation (Plio-Pleistocene). Unconformably overlying the Neroly formation, the Tulare formation crops out along the west border of the San Joaquin Valley. The formation is mainly fluviatile in origin, consisting of poorly sorted brown sandstone, gravel, and clay (Anderson and Pack, 1915, p. 101). Much of the material in the Tulare formation is Franciscan detritus. Fossils found in the formation place the age as ranging from Pliocene to late Pleistocene (Huey, 1948, p. 49).

East Side

The eastern margin of San Joaquin County lies in the foothills of the Sierra Nevada. The Sierra Nevada is a westward tilted fault block nearly 400 miles long composed of slate, schist, and gneiss that have been intruded by igneous rocks and are overlain by a series of Upper Cretaceous and Tertiary sedimentary and volcanic rocks. No Sierran bedrock is exposed in San Joaquin County; however, weathered products from these rocks constitute a major part of the later Tertiary formations in this county.

Rock Formations

Valley Springs Formation (Middle ? Miocene). Occurring in small patches in the northeastern part of San Joaquin County, the Valley Springs formation is composed of fragmental glassy rhyolite tuff, pumice, and small amounts of quartz conglomerate, forming nearly horizontal beds. On the basis of stratigraphic relationships, the Valley Springs is assigned to the middle (?) Miocene (Piper and others, 1949, p. 78).

Mehrten Formation (Upper ? Miocene and Pliocene). Unconformably overlying the Valley Springs formation is the Mehrten formation. It is a fluviatile deposit consisting chiefly of andesitic detritus with smaller amounts of sandstone, siltstone, and conglomerate. On the basis of fossils found at Table Mountain in Tuolumne County, the Mehrten is classified as Miocene and lower Pliocene in age (Piper and others, 1939, p. 71).

Laguna Formation (Pliocene?). The Laguna formation underlies an extensive area in northeastern San Joaquin County, although it is poorly exposed. It is fluviatile in origin, consisting of silt and sand with smaller amounts of gravel and clay. This formation presumably forms a large lens dipping gently westward on the slightly tilted Mehrten formation (Piper and others, 1939, p. 58). On the basis of stratigraphic relationships, the Laguna formation is thought to be Pliocene and possibly early Pleistocene in age (Piper and others, 1939, p. 60).

Arroyo Seco Gravel (Pleistocene). Arroyo Seco gravel is the name given to discontinuous beds of streamborne detritus found in northeastern San Joaquin County that were deposited from the old land surface to the east known as the Arroyo Seco pediment which existed during Pleistocene time (Piper and others, 1939, p. 54). This detritus is composed largely of coarse sand and gravel enclosed in brick-red soil.

Victor Formation (Pleistocene). The Victor formation crops out extensively on the east side of the San Joaquin River as well as in patches near the eastern margin of the county. It is a fluviatile deposit that rests on the dissected Arroyo Seco pediment (Piper and others, 1939, p. 45).

The deposit consists of beds of sand, silt, gravel, and unconsolidated lenses of sandstone and siltstone, in places well-stratified and well-sorted. The grains, which are poorly rounded, consist largely of quartz, feldspar, and mica, with local concentrations of magnetite, hornblende, and pyroxene (Piper and others, 1939, p. 41). Size of the individual grains in the beds varies greatly.

The Victor formation is believed to be largely of late Pleistocene age, chiefly because it was deposited after the early Pleistocene tilting of the Sierra Nevada and after the Arroyo Seco pediment had been cut along the flank of the tilted mountain block (Piper and others, 1939, p. 49). Piper found a few fragmental vertebrate fossils in this formation, but they did not indicate any particular stage of the Pleistocene epoch.

San Joaquin Valley

The largest part of San Joaquin County lies in the Great Valley of California, a northwest-trending geosyncline that has its axis along the west side. In San Joaquin County, the valley floor is near sea level. It is underlain by sedimentary rocks that are at least 20,000 feet thick in San Joaquin County and consist predominantly of marine sandstone and shale ranging from Cretaceous to late Tertiary age. Basement rocks lying beneath them include metamorphosed sedimentary and volcanic rocks and later intruded igneous rocks. The Franciscan formation constitutes the basement rock on the west side of the county; basement on the east side is the Sierra Nevada granitic complex.

Tertiary Formations beneath the San Joaquin Valley Floor. Several Tertiary formations not exposed in the county are encountered in natural gas wells in northern San Joaquin County. For example, the following Tertiary formations have been encountered in wells in the McDonald Island gas field: Markley (upper Eocene), Domengine (middle Eocene), Capay (lower Eocene), and Martinez (Paleocene). At the Thornton gas field, the Meganos formation (lower Eocene or upper Paleocene) is encountered, while the Nortonville formation (upper Eocene) is found in wells in the Lodi gas field.

Alluvium (Recent). Recent alluvium is composed of silt, sand, and gravel found in the present stream channels and beneath flood plains in the valley as well as along both the east and west sides and in the delta region. Further additions are being made by the streams, or would be made under natural conditions (Piper and others, 1939, p. 34).

In the northwest part of San Joaquin County in the delta region, the land is near sea level, and the stream-borne alluvium is more or less intermingled with tidal muck and peat. The many levees in this area have prevented the periodic inundation of the region.

Geologic History

During Upper Jurassic time, a sea occupied the slowly sinking geosynclinal basin lying between the ancestral Sierra Nevada and a large landmass west of the present Coast Ranges. This sea covered most of what is now San Joaquin County. Sediments derived from the western landmass and the ancestral Sierra Nevada were deposited in this basin. Toward the end of this period, considerable amounts of radiolarian chert, some of it manganiferous (Taliaferro, 1943a, p. 126), were deposited in the southwestern portion of the county.

Near the end of the Jurassic period, mountain building processes in both the ancestral Coast Ranges and the Sierra Nevada caused an almost complete withdrawal of the sea from the Great Valley area. In the ancestral Sierra Nevada, where this mountain building is known as the Nevadan orogeny, the sediments were folded, metamorphosed, and intruded by ultrabasic, basic, and granitic igneous rocks (Jenkins, 1943, p. 91). Chromite and platinum-group metal mineralization accompanied the intrusion of the ultrabasic rocks. This was followed by hypothermal deposition of gold and silver in rocks that were the original source of most of the placer gold and silver in the county. In the central Coast Ranges, where this mountain building disturbance is known as the Diablan orogeny, there was widespread uplifting (Taliaferro, 1943a, p. 127) and some basic intrusion.

A period of intensive erosion followed during Cretaceous time, providing great thicknesses of sedimentary material. In late Cretaceous time, the sea again covered much of what is now San Joaquin County. Organic sediments deposited at that time formed the source materials for gas in the natural gas fields of the western portion of the county. During the middle, and again in the late part of the Cretaceous period, orogenic processes affected various parts of the central Coast Ranges (Taliaferro, 1943a, p. 130).

Mild uplifting continued in the Coast Ranges into the early part of the Eocene epoch (Jenkins, 1943, p. 92). Erosion also continued, washing products into a shallow sea that occupied much of the Great Valley region during the Paleocene and Eocene epochs. The climate was subtropical, aiding the agents of deep chemical weathering. Lignite, high-grade clay, and quartz sand formed in this environment accumulated outside the east and west margins of the county; organic debris in marine sediments laid down in Eocene time gave rise to important natural gas deposits in central San Joaquin County; and in the ancestral Sierra Nevada, gold was eroded from bedrock and deposited in Eocene stream channels.

There are no rocks of the Oligocene epoch recognized in San Joaquin County.

In the Miocene epoch, sediments were deposited in the area of the Coast Ranges. At the same time, fragmental andesite and rhyolite were deposited in eastern San Joaquin County as part of the widespread volcanism in the Sierra Nevada. The Eocene stream channels in the Sierra Nevada were choked with volcanic debris resulting in a change in the drainage pattern.

Volcanic activity waned during Pliocene and Pleistocene times. In upper Pliocene time, strong folding and general uplifting of the Coast Ranges caused the withdrawal of the sea from the Great Valley (Taliaferro, 1943a, p. 146). Continental sediments were deposited in eastern and western San Joaquin County in late Pliocene-early Pleistocene time.

During the Pleistocene epoch, the Sierra Nevada was re-elevated to a great height. (Jenkins, 1943, p. 93), while further folding and faulting occurred in the Coast Ranges. Deep canyons were cut in the higher mountains and debris from them provided large amounts of sand and gravel, that were deposited in eastern San Joaquin County. The climate became colder toward the end of Pliocene time and by Pleistocene time, glaciers had developed in the higher portions of the Sierra Nevada.

The products of continued erosion of the Sierra Nevada in Pleistocene and Recent times supplied gold to the placers in the eastern portion of the county and large amounts of sand and gravel to the southwestern part. Introduction of the Recent epoch saw retreat of the glaciers from the Sierra Nevada and the final development of the present landscape and climate.

Table 1. Mineral production of San Joaquin County, 1885-1951.

Year	Brick		Natural gas		Sand and gravel		Manganese		Miscellaneous stone, value[4] (dollars)	Miscellaneous and unapportioned		
	M	Value (in dollars)	M cu. ft.	Value (in dollars)	Short tons	Value (in dollars)	Tons	Value (in dollars)		Amount	Value (in dollars)	Substance
1885	---	---	---	---	---	---	[1]	---	---		$2,500	Gold
1886	---	---	---	---	---	---	---	---	---	---	---	
1894	---	---	---	$75,000	---	---	55	$550	---	275 tons	343	Pottery clay
1895	---	---	---	100,000	---	---	280	2,800	---	---	---	
1896	7,000	$35,000	---	85,157	---	---	---	---	---	---	---	
1897	5,500	22,000	---	57,411	---	---	---	---	---	---	---	
1898	6,500	34,000	---	57,289	---	---	---	---	---	---	---	
1899	5,500	27,000	102,960	84,880	---	---	---	---	---	---	---	
1900	2,000	20,000	27,000	19,862	---	---	---	---	---	---	---	
1901	2,000	20,000	---	60,456	---	---	---	---	---	---	---	
1902	[2]3,000	[2]18,000	81,481	67,868	---	---	---	---	---	273 tons	2,730	Asphalt
1903	[2]4,000	[2]24,000	88,134	44,399	---	---	---	---	---	3 tons	90	Infusorial earth
1904	7,500	45,000	106,437	47,635	---	---	---	---	---	---	---	
1905	11,400	68,000	100,950	53,915	---	---	---	---	$25,000	---	---	
1906	7,500	49,500	103,450	55,115	---	---	---	---	---	---	---	
1907	12,250	81,000	101,000	52,723	---	---	---	---	---	---	---	
1908	28,412	189,560	60,903	49,194	---	---	60	1,080	---	2,000 tons	13,000	Clay
1909	8,088	242,634	71,883	149,063	---	---	---	---	---	---	214,835	Unapportioned, 1900-1909
1910	8,744	212,538	313,392	159,451	---	---	260	4,160	---	---	---	
1911	5,275	49,650	---	114,433	---	---	---	---	---	25,510 tons	25,510	Clay
1912	6,128	64,874	---	145,166	---	---	---	---	---	---	---	
1913	6,314	73,768	142,730	67,967	1,800	$900	---	---	---	1,494 tons 3,000 tons	18,522 4,000	Clay Glass sand
1914	5,793	82,890	154,872	25,900	38,880	19,440	150	1,500	---	---	200	Other minerals
1915	3,000	75,000	161,923	143,974	43,240	21,620	460	7,400	---	---	400	Other minerals
1916	10,189	158,722	182,441	141,605	88,247	37,300	6,493	115,460	15,775	---	---	
1917	also tile	185,060	348,146	72,585	165,721	47,090	6,320	157,500	7,913	---	72	Other minerals
1918	---	305,475	202,453	60,405	117,874	42,767	4,281	117,709	4,308	---	71,799	Gold, platinum, silver
1919	---	231,478	200,943	76,200	130,119	59,510	343	10,274	---	---	71,538	Gold, platinum, silver
1920	---	[3]	200,433	74,957	151,390	63,077	[3]	---	---	---	333,068	Brick, gold, manganese, platinum, silver
1921	---	294,712	204,057	79,571	149,361	67,415	425	3,750	5,400	---	23,530	Other minerals
1922	---	[3]	199,389	62,454	212,690	87,967	[3]	---	[3]	--- ---	314,269 96,672	Brick and clay Manganese ore, misc. stone
1923	---	[3]	---	[3]	503,611	260,543	---	---	54	--- ---	472,858 77,774	Brick and clay Manganese ore, nat gas

1924	14,936	$462,688	----------	3	155,547	$79,504	--------	----------	$4,370	----------	$55,938	Manganese ore, nat. gas
1925	also tile	472,983	----------	----------	569,579	102,737	--------	----------	500	----------	161,598	Other minerals
1926	also tile	511,448	----------	----------	221,338	129,037	--------	----------	--------	----------	201,505	Other minerals
1927	also tile	630,218	----------	----------	258,564	81,847	--------	----------	--------	----------	----------	
1928	also tile	512,425	----------	----------	367,703	63,444	--------	----------	--------	----------	49,062	Unapportioned
1929	also tile	607,469	----------	----------	254,893	102,817	--------	----------	32,500	----------	47,105	Unapportioned
1930	11,858	478,454	----------	----------	220,683	196,857	--------	----------	5,450	----------	44,101	Unapportioned
1931	also tile	308,217	----------	----------	178,059	87,673	--------	----------	32,056	----------	34,250	Unapportioned
1932	3	----------	3	----------	161,004	58,679	--------	----------	18,022	6 oz.	2	Silver
										----------	1,440	Gold
										----------	192,349	Brick and natural gas
1933	3	----------	3	----------	102,589	47,976	--------	----------	1,937	4 oz.	1	Silver
										----------	1,017	Gold
										----------	102,196	Brick and hollow building tile, and natural gas
1934	3	----------	3	----------	121,148	59,830	--------	----------	17,677	----------	1,133	Gold
										3 oz.	2	Silver
										----------	69,455	Brick and hollow building tile, natural gas
1935	3	----------	3	----------	171,130	86,192	--------	----------	6,861	----------	99,698	Gold
										----------	109	Silver
										----------	223,408	Brick and hollow tile, natural gas
1936	3	----------	3,104,068	$294,457	268,302	129,923	--------	----------	3,767	----------	32,917	Brick, gold, silver
1937	----------	----------	5,740,226	484,381	161,066	88,624	--------	----------	7,245	----------	79,765	Gold
										----------	125	Silver
										----------	46,480	Other minerals
1938	----------	----------	5,720,352	503,667	348,019	165,658	--------	----------	9,872	----------	41,580	Gold
										----------	59	Silver
										----------	61,071	Other minerals
1939	----------	57,394	10,432,694	834,694	210,004	117,664	--------	----------	28,705	----------	66,185	Gold
										----------	144	Silver
										----------	112	Other minerals
1940	3	----------	9,037,712	574,452	240,573	139,189	--------	----------	36,249	----------	329,175	Gold
										----------	648	Silver
										----------	67,199	Brick and hollow tile, pottery clay, platinum
1941	3	----------	10,105,068	659,137	335,397	204,322	--------	----------	47,579	----------	830,935	Gold
										----------	1,430	Silver
										----------	89,216	Other minerals
1942	3	----------	11,829,675	839,502	785,611	448,156	3	----------	26,874	1,894 tons	4,782	Pottery clay
										----------	633,605	Gold
										----------	1,253	Silver
										----------	124,906	Brick and hollow tile, manganese ore, platinum

Table 1. Mineral production of San Joaquin County, 1885-1951.—Continued.

Year	Brick		Natural gas		Sand and gravel		Manganese		Miscellaneous stone, value[4] (dollars)	Miscellaneous and unapportioned		
	M	Value (in dollars)	M cu. ft.	Value (in dollars)	Short tons	Value (in dollars)	Tons	Value (in dollars)		Amount	Value (in dollars)	Substance
1943	[3]	----------	12,446,567	$888,205	514,552	368,829	[3]	----------	$39,475	----------	$177,450	Gold
										----------	314	Silver
										----------	147,338	Brick and hollow tile, manganese ore, platinum
1944	[3]	----------	11,337,469	798,908	364,917	230,028	[3]	----------	55,989	----------	284,273	Brick and hollow tile, manganese ore, gold, silver
1945	[3]	----------	9,377,104	670,838	372,945	216,301	[3]	----------	10,230	7,343 oz.	257,005	Gold
										754 oz.	536	Silver
										----------	101,684	Brick and hollow tile, pottery clay, manganese ore
1946	[3]	----------	9,524,708	987,399	1,001,433	684,182	----------	----------	21,251	13,715 oz.	480,025	Gold
										1,361 oz.	1,100	Silver
										----------	56,604	Brick and hollow tile, pottery clay, platinum
1947	[3]	----------	9,650,000	1,261,000	1,598,607	1,330,544	----------	----------	[3]	----------	291,000	Clay products
										----------	340,876	Raw clay, gold, silver, stone
1948	[3]	----------	8,277,000	1,313,000	1,697,808	1,617,023	----------	----------	[3]	----------	274,000	Clay products
										18,184 tons	14,259	Raw clay
										----------	133,533	Gold, silver, stone, platinum metals
1949	[3]	----------	6,341,000	849,000	1,424,586	1,349,904	----------	----------	[3]	19,803 tons	15,557	Clays
										----------	288,076	Gold, silver, stone
1950	[3]	----------	6,213,000	868,000	1,509,960	1,350,898	----------	----------	[3]	----------	343,958	Clay, gold, silver, stone
1951	[3]	----------	5,465,038	1,027,427	1,866,075	1,095,331	----------	----------	[3]	----------	304,983	Clay, gold, platinum, silver, stone
Totals	----------	$6,651,157	----------	$15,138,702	17,067,025	$11,340,798	[3]19,127	$422,183	[3]$465,059	----------	$8,951,747	

GRAND TOTAL VALUE......$42,969,646

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[1] Production of manganese ore in California began at the Ladd Mine, San Joaquin County, in the Tesla district in 1867. When shipments of this ore to England ceased late in 1874, upwards of 5,000 tons had been produced by that property. Annual amounts earlier than 1894 are not separable.

[2] Estimated.

[3] See under "Unapportioned."

[4] Includes crushed rock, rubble, rip-rap.

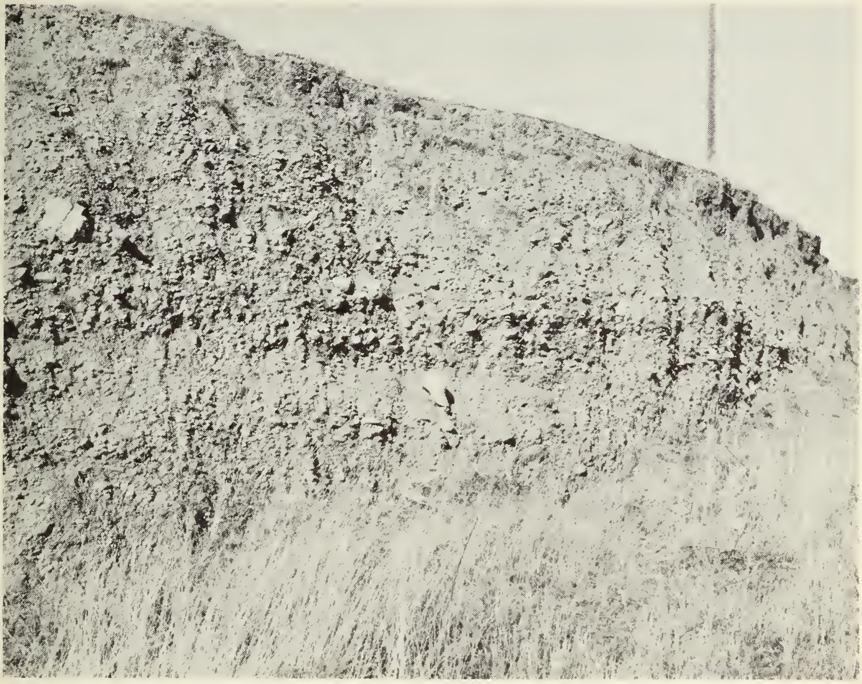

FIGURE 2. Sand and gravel deposit in alluvial fan at the mouth of Corral Hollow Canyon.

MINES AND MINERAL RESOURCES

The value of total recorded mineral production of San Joaquin County from 1885 to 1951 is $42,969,646. Natural gas, sand and gravel, brick and clay, manganese, and gold have been the principal products. In 1951, minerals produced in San Joaquin County were valued at $3,027,741, ranking it the 23rd county in order of value of mineral output in the state. Not included in this total is the value of output of the mineral-processing and mineral-utilizing industries. Sand and gravel is the most important mineral product of the county, followed in value by natural gas. Other important mineral commodities in 1951 were clay and gold, but since 1951, little or no gold has been produced in the county.

Clay and Clay Processing

Although production figures for clay in San Joaquin County in recent years are not available, substantial quantities are quarried and processed in the county. At the present time, there are three plants that manufacture common brick, sewer pipe, and hollow and drain tile while a fourth plant manufactures various types of dinnerware. Clay is produced from pits at two of these plants for the manufacture of common brick, but it is necessary to import a substantial portion of the clay from Amador, Calaveras, and Stanislaus Counties and some ball clay is imported from Tennessee.

Clay and clay products have been produced in the county for many years. In 1888, the San Joaquin Improvement Company operated a brickyard and clay pit in Stockton, (Irelan, 1888, p. 561). A large brick and terra cotta plant was operated in Corral Hollow by the Carnegie Brick and Pottery Company during the period of 1904-12. Clay used in this plant was obtained from the Tesla coal and clay mine in Alameda County (Lowell, 1914, p. 607). Ruins of this plant are still visible. In 1906, there were three brick plants in operation, 5 to 6 miles southwest of Stockton at Roberts Island (Aubury, 1906, pp. 254-255).

From 1912 until 1932, fire brick was produced in a plant at Stockton by the Stockton Fire Brick Company. Raw clays from Amador and Placer counties were used. The stiff mud process was used and the bricks were fired in special down-draft kilns. The products were both shipped abroad and used locally (Laizure, 1925, p. 189).

Common alluvial clay and clay soils ranging from Pleistocene to Recent in age are common in central San Joaquin County. In the Stockton region and along the San Joaquin River, orange and red-burning clay and clay soils are interbedded with unconsolidated sand and gravel; clay pits excavated in this region are from 20 to 40 feet in depth. Minor amounts of fire clay are found in the Tesla formation (middle Eocene) in the Corral Hollow area near the Alameda County line.

Laurel Pottery Company. Location: McKinley Avenue in the southern part of Stockton. Ownership: Laurel Pottery Company, McKinley Avenue, Stockton. William Glabb is plant superintendent and W. E. Lee is ceramist.

The Laurel Pottery Company plant, originally erected in 1935, manufactures all lines of dinnerware which are retailed in department stores and mail order houses throughout the country. Among the brands are California Living, Mariposa Modern, Parade, and Holiday.

Raw materials used at this plant include ball clay from Tennessee, semi-ball clay from Knight's Ferry, California, and steatite talc from San Bernardino County, California. About 150 tons of ball clay, 300 tons of semi-ball clay, and 300 tons of talc are used annually at the plant.* Smaller amounts of feldspar, soda ash, and nearly all types of oxide pigments are also used. Clay utilized at the plant must not contain more than a trace of iron oxide.

The raw material is ground to about 200 mesh and screened, then mixed in a pug mill with water and either molded or cast into the desired shapes. Flat pieces such as plates and saucers are shaped in molds made of pottery plaster that are manufactured at the plant; deep pieces such as coffee pots are cast.

The molded or cast pieces are then baked in a gas-fired continuous kiln to a rough finish. The pieces are then glazed and fired a second time in another continuous kiln. The finished products are packed in boxes and shipped by truck.

When in full production about 125 persons work at the plant.

Pacific Clay Products Company. Location: California and Ninth Streets, Stockton, California. Ownership: Pacific Clay Products Company, Box 145, Station A, Los Angeles, California. J. A. Simpson is plant superintendent and M. Kreston is plant engineer.

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* Lee, W. E., personal communication, 1953.

All sizes of tile pipe and a complete line of sewer pipe are produced at this plant, amounting to approximately 2000 tons of finished products per month.

Crude clay, largely from Valley Springs but some from the Dosch clay pit near Ione, is shipped in by railroad. Occasionally some fill clay from the Livermore area is used. The clay is bulldozed into storage sheds at the plant. Loaders deliver the clay from the sheds to a dry pan grinder in which the material is ground to about 10-mesh. The ground clay is then screened and delivered by belt conveyor to overhead storage bins, from which it is fed to a pug mill and mixed with water. The mixed material is then shaped in vertical hydraulic presses, which can shape sewer pipe sections up to 8 feet in length and 3 feet in diameter.

The shapes are taken by lift truck to the hot floor, a large building that is heated by hot air circulating through ducts under the floor, where they are dried for a day or more depending upon their size. The larger shapes, after drying, are trucked to one of two gas-fired downdraft periodic kilns. The kilns, which were built early in 1953, are rectangular in shape and constructed of insulating brick; a normal charge of 200 to 400 tons of shapes is fired at a temperature of 2150° F. Time of firing varies with the size of the shapes, but the average cycle of firing and cooling is approximately two weeks. Waste heat from the kilns is used to heat the hot floor building. The smaller shapes are fired in beehive-type kilns.

A testing laboratory at the plant maintains close control on the quality of both incoming raw materials and of the finished product. Eighty men work at the plant.

San Joaquin Brick Plant. Location: the east side of Roberts Island, 5 miles southwest of Stockton. Ownership: Stockton Building Materials Company, 711 South Mason Street, Stockton, California. Ted Mason is plant superintendent.

This plant was erected in 1906 (Aubury, 1906, p. 254). About 1914, it was consolidated with the Roberts Island Brick Company plant (Lowell, 1914, p. 608). The plant was owned and operated by the San Joaquin Brick Company until 1950, when it was sold to the Stockton Building Materials Company.

Common red brick, marketed largely in the Stockton area, is the only product. During the season of plant operation from May until September, approximately 80,000 bricks per day are manufactured.*

A clay pit just west of the plant is the source of raw material for the plant. The deposit, which is Recent in age, consists of alluvial reddish-brown clay with a silty soil overburden. The clay bed is 20 feet thick while the overburden is about 5 feet thick. The clay pit is approximately 20 acres in extent.

At the pit, the clay is excavated by a dragline and deposited in a stockpile. An entire year's supply is stockpiled during the fall so that winter rains aid in leaching out impurities. From time to time the stockpile is bulldozed to expose all of the clay to the rain.

When the plant is operating, clay from the stockpile is trucked to an underground bunker, from which it goes through a smooth-roll crusher and then is belt conveyed to an overhead hopper. The material is then screened and the chunks are delivered to a Marcy mill which

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* Mason, Ted, personal communication, 1953.

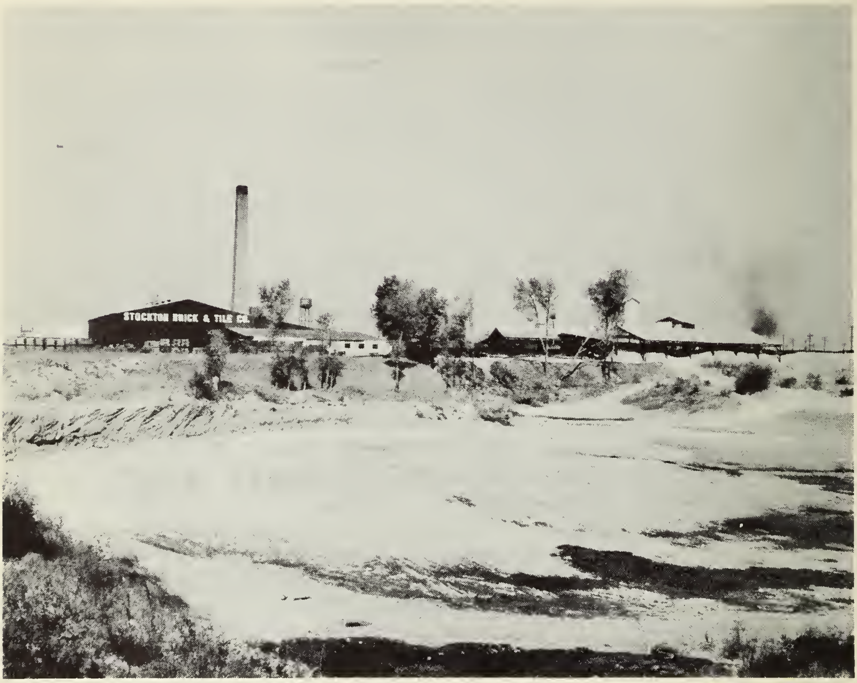

FIGURE 3. Clay pit and brick plant of the Stockton Brick and Tile Company, Stockton.

discharges to the conveyor belt. Fine material is sent to a Steel combination pug mill and extruder. The extruded mud is cut in a revolving wire cutting machine and the wet shapes are then sent to a delivery table.

From the delivery table, the wet brick shapes are taken to a shed where they are air dried for several days. The shapes are then carted to a coal-fired Hoffman 16-section continuous kiln. Each section is fired for about 24 hours. The finished bricks are then stockpiled.

During the operating season 35 men work at the plant.

Stockton Brick and Tile Company. Location: In the southern part of Stockton on McKinley Avenue and the Western Pacific Railroad tracks. Ownership: Stockton Brick and Tile Company, P. O. Box 547, Stockton, California. E. W. Harker is general manager and plant superintendent.

This plant was erected in 1921 (Laizure, 1925, p. 188). Various grades of common brick, hollow tile, and drain tile are produced. The tile is marketed throughout the state while the bricks are sold largely in the Stockton area and northward. Production is approximately 1000 tons of finished products per month.

Nearly all of the clay used at the plant is produced from a pit just south of the plant. The clay is an orange red-burning variety which occurs in flat-lying beds. There is very little overburden. The pit is approximately 50 feet deep and several acres in extent. The clay is mined under contract at the pit with a tractor and a small carry-all scraper and stockpiled in a shed. Occasionally some clay is shipped in by rail from the Ione area in Amador County.

The stiff mud process is used at the plant. The clay is ground in a dry pan grinder, screened, and elevated to a pug mill. In the pug mill, the clay is mixed with water to form a mud which is sent to an extruder. A continuous stream of shaped mud from the extruder, is wire cut to standard brick sizes. The brick shapes are then air dried for about four days.

The dried shapes are then carted to field-type kilns where they are baked for 11 days. There are four field-type kilns, each having a capacity of 250,000 bricks. Hollow and drain tile shapes are carted to a coal and gas-fired Hoffman 16-section continuous kiln. Each section is fired for about 24 hours. Finished bricks and tiles are then stockpiled in the yard.

Thirty-two men work at the plant.

Glass Sand

There is an abandoned glass sand prospect located on the San Joaquin-Alameda County line in sec. 32, T. 3 S., R. 4 E., M. D. M. in Coral Hollow Canyon. This prospect is in sands of the Tesla formation (middle Eocene), which are high in quartz and low in ferromagnesian mineral content (Huey, 1948, p. 61).

From 1901 to 1921, window glass and glass products were manufactured at two plants in the Stockton area. Glass sand used at these two plants was imported from Monterey County.

Gold

Gold occurs in placer deposits along the eastern margin of San Joaquin County. Most of the gold operations have been on or near the Mokelumne River between the towns of Clements and Camanche and on the Calaveras River near the towns of Bellota, Linden, and Jenny Lind.

During the latter part of the nineteenth century, small amounts of gold were produced in northeastern San Joaquin County from workings along the Mokelumne River. Most of this work was done by Chinese (Irelan, 1888, p. 562). From 1918 to 1920, the American Gold Dredging Company operated a dredge in San Joaquin County on the Mokelumne River in the Camanche district (Laizure, 1925, p. 191). From 1935 until 1951, various dredging companies were active in the county. The largest operation was that of the Gold Hill Dredging Company on the Mokelumne River between Clements and Camanche.

Associated with the gold are heavy resistant minerals such as magnetite, ilmenite, zircon, and garnet, as well as minor amounts of silver and platinum-group metals.

Gold Hill Dredges. Ownership: Gold Hill Dredging Company, 311 California Street, San Francisco, California, J. J. Coney, President, L. R. Kerdell, Secretary-Treasurer, H. S. Gilbert, Assistant Secretary.

The Gold Hill Dredging Company began operating in San Joaquin County in 1939 when it was consolidated with the Camanche Gold Dredging Company. This latter company began dredging operations in the Camanche district on the Mokelumne River in 1935. Besides San Joaquin County, the company operated on properties in Calaveras, Sacramento, Placer, Amador, and Butte Counties. In June, 1951, all dredging operations of the Gold Hill Dredging Company ceased with the closing of the ''Lower Camanche'' dredge west of Clements.

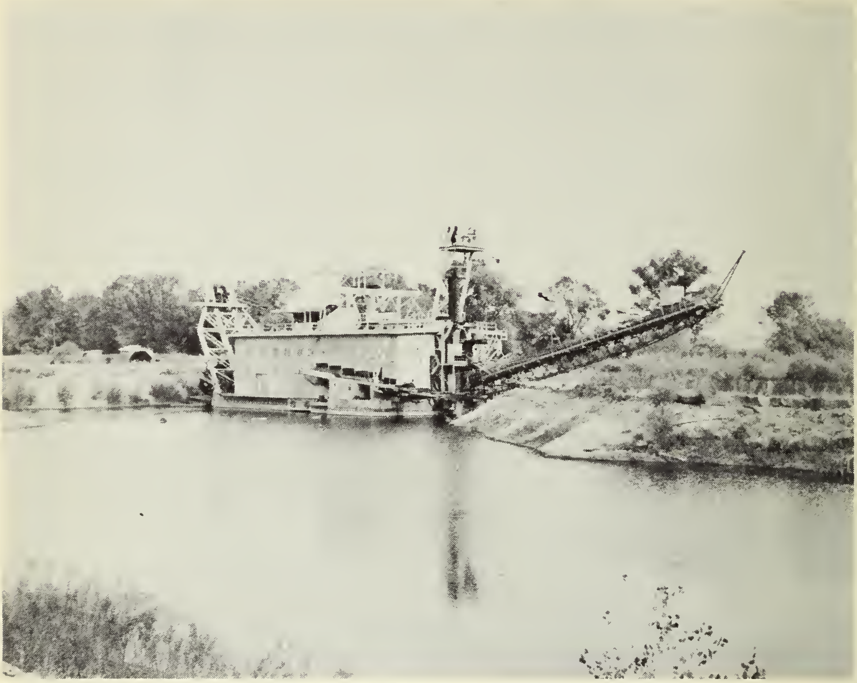

FIGURE 4. The "Lower" Camanche dredge of the Gold Hill Dredging Company a mile west of Clements.

Dredging operations in San Joaquin and Calaveras Counties extended for a distance of about 10 miles along the Mokelumne River from near the town of Camanche, Calaveras County, to about a mile southwest of the Clements-Ione Bridge in San Joaquin County. Two floating connected-bucket dredges were employed; one known as the "Upper" Camanche dredge and the other the "Lower" Camanche dredge. The upper dredge ceased operations in January, 1949, 3 miles northwest of Clements near where Murphy Creek joins the Mokelumne River. The lower dredge ceased operations in June, 1951, on the Featherston Ranch, a mile west of Clements. Both of the idle dredges remain at these locations.

The gravels mined by the two dredges were in and near the channel of the Mokelumne River, where the gravel is unconsolidated and contains very little clay. The gravels worked by the two dredges ranged from 16 to 50 feet deep. Overburden, which consists largely of silt and soil, ranges from less than a foot to 10 feet in thickness. Gold recovered from the eastern part of the company's operations amalgamated readily and was easily saved in riffles. As operations along the river progressed westward, the gold particles became finer and jigs were installed in the dredges to insure the most complete recovery possible. The gold was between 850 and 900 in fineness. Very little platinum was recovered.

The "Upper" Camanche dredge has a hull dimension of 110 by 60½ by 7½ feet. Its average digging depth was 43 feet below the water level. When operating, approximately 150,000 cubic yards of material were handled each month. The lower dredge has a hull dimension of 140½ by 48 by 10 feet. Average digging depth of the lower dredge was 35 feet, and it handled 250,000 cubic yards of material per month. Both dredges are equipped with riffles and Pan American jigs.

Lignite

Lignite occurs in narrow seams associated with shale in the vicinity of Corral Hollow and Lone Tree Creeks in the southwestern part of San Joaquin County. Some prospecting work was done on a lignite seam near the headwaters of Lone Tree Creek in 1890 (Watts, 1890, p. 564).

The lignite in San Joaquin County occurs in the middle Eocene Tesla formation (Huey, 1948, p. 33). The seams of lignite are interbedded with shale, quartz sand, and clay which were deposited in lagoons and swamps in a sub-tropical climate.

Limestone

From 1900 until about 1911, small amounts of limestone were produced from a deposit in the southeast corner of section 33, T. 3 S., R. 4 E., about half a mile south of Carnegie in Corral Hollow Canyon. The limestone was burned in an oil-fired kiln at the Carnegie Brick and Pottery Company plant. (Aubury, 1906, p. 79). Some limestone was also shipped to a glass-making plant in Stockton.

The deposit consists of veins of spar and travertine composed of aragonite which was probably deposited by hot springs along the Tesla fault zone (Huey, 1948, p. 62). The veins range from 3 inches to 3 feet in width and dip about 65 degrees northeast. The deposit is overlain by iron oxide-stained shale of the Panoche (Upper Cretaceous) formation.

Manganese

The largest source of manganese ore in California has been the Ladd-Buckeye area of San Joaquin and Stanislaus Counties (Trask and others, 1950, p. 211). Manganese ore was first produced in San Joaquin County in 1867 when the Ladd mine was opened. Production from the Ladd area in the county continued until around 1900. The mines were reopened during World War I and produced a total of about 14,000 tons of manganese ore. After 1921, there was no production in the county until World War II.

During World War II, several thousand tons of manganese ore were produced from the Mahoney and Cummings mines in the Ladd area. Also at this time the U. S. Geological Survey made a detailed study of the manganese deposits in the county, and the U. S. Bureau of Mines explored the Ladd mine by means of diamond drilling and crosscutting. The results of these studies were published in California Division of Mines Bulletins 125 and 152.

In 1950, the Taylor-Knapp Company reopened the Ladd mine and erected a beneficiation plant to treat the ore produced at the mine. Concentrates produced in the plant are used in the dry-cell battery industry.

The Ladd-Buckeye area, which is about 12 miles long and 2 miles wide, is in the Coast Ranges, about 12 miles south of Tracy. The manganese deposits occur in a northwest-trending belt of rocks of the Franciscan formation. In this area of the Coast Ranges, the formation is more than 10,000 feet thick.

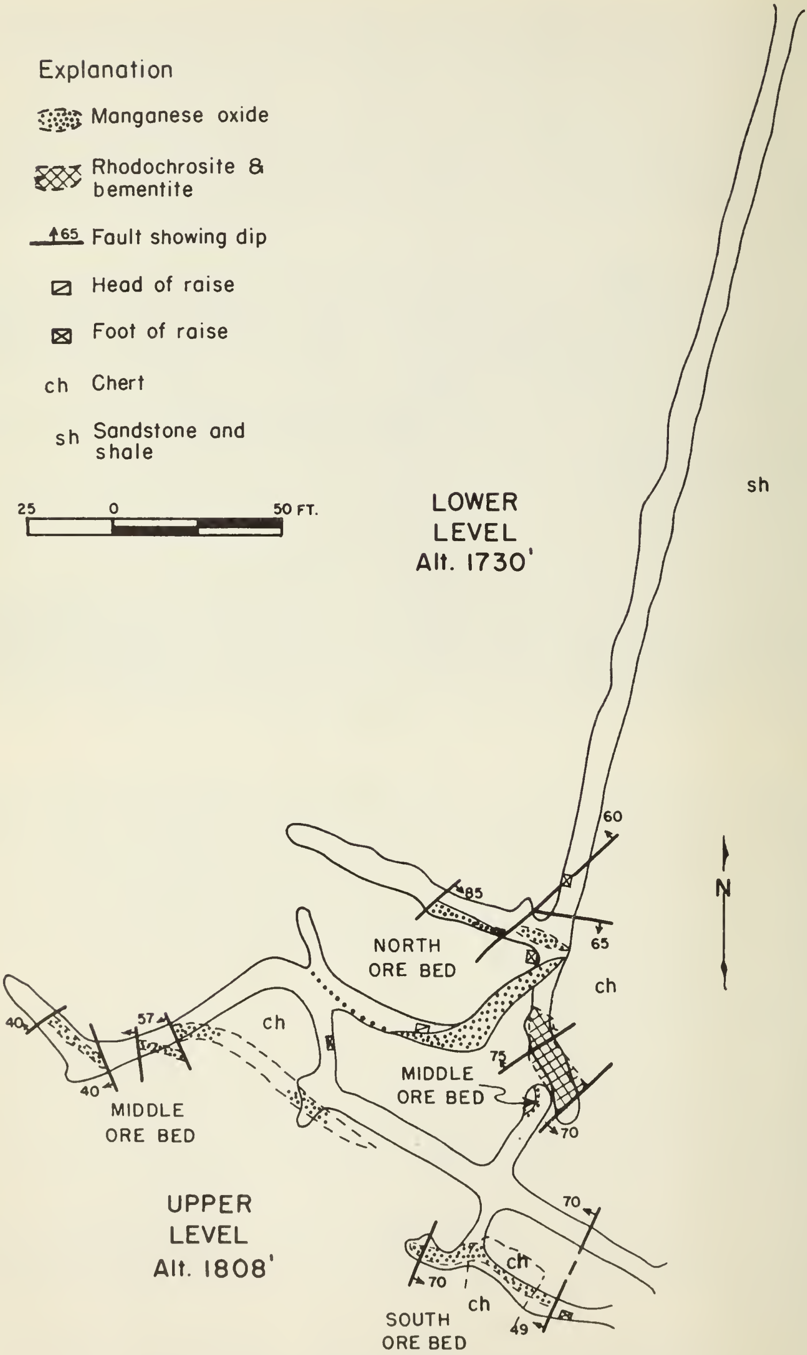
Explanation
Manganese oxide
Rhodochrosite & bementite
65 Fault showing dip
Head of raise
Foot of raise
ch Chert
sh Sandstone and shale
25 0 50 FT.
LOWER LEVEL Alt. 1730'
sh
60
85
65
NORTH ORE BED
ch
40
57
ch
40
MIDDLE ORE BED
75
MIDDLE ORE BED
70
UPPER LEVEL Alt. 1808'
70
ch
70
ch
49
SOUTH ORE BED
N

FIGURE 5. Map of the geology and underground workings of the Cummings manganese mine. *Modified after Trask and others, 1950.*

Manganese ore occurs as lenses in massive beds of white chert interbedded with sandstone and shale. Two types of ore are found: massive oxide ore and disseminated oxide ore. The principal primary mineral in the massive type is fine-grained gray rhodochrosite whereas in the disseminated type it is a mixture of rhodochrosite and bementite in chert (Trask and others, 1950, p. 217). The ore bodies range from a few to 800 feet in length and from 4 to 10 feet in width; the main ore body at the Ladd mine is 35 feet wide. The ore lenses are roughly elliptical in outline.

Cummings (Lone Tree, Section 13) mine. Location: sec. 13, T. 4 S., R. 4 E., M.D.M., 1½ miles southwest of the Ladd mine and 10 miles southwest of Tracy. Ownership: J. A. Rustan, Rt. 2, Box 292, Tracy, California.

In 1916, the Cummings manganese mine was operated by the Manganese Company of California (Trask and others, 1950, p. 221). In 1917, it was leased to J. J. and F. E. Cummings who operated it until 1919. During this period, 2,250 tons of ore averaging 46 percent manganese was produced (Trask, and others, 1950, p. 221).

The Lone Tree Mining Company of San Francisco leased the property from September, 1941 until November, 1942 (Bruce, T. A. C., personal communication, 1953). During this time, old workings were rehabilitated and a small amount of exploration work was done. A total of 72 short tons of ore containing 40 to 53 percent manganese oxide and valued at $1,319.36 was shipped to the Metals Reserve stockpile at Tracy (Bruce, T. A. C., personal communication, 1953). The mine has been idle since 1942.

Three northwest-trending ore beds, the north, middle, and south beds, occur in a belt of Franciscan chert at intervals of 75 feet. The ore in the north and south beds and the northern part of the middle ore bed consists of black manganese oxide. The south part of the middle ore bed is composed of rhodochrosite and bementite. Dip is approximately 60° to the northeast.

The north bed, which contained the best ore, extends 85 feet along the strike, is 150 feet in depth, and averages 4 feet in width. This bed is largely mined out. The highly faulted middle ore body is a manganiferous zone extending about 150 feet along the strike. This body contains the largest ore reserves remaining in the mine (Trask and others, 1950, p. 222). Estimated grade of this ore, which is largely rhodochrosite and bementite, is 20 to 25 percent. The south ore bed is about 50 feet long and has a maximum width of 5 feet. Only small amounts of ore of economic grade were recovered from this bed.

The mine is developed by several open cuts and two adits. The lower south-trending adit, which is at an elevation of 1730 feet, crosscuts the north ore bed about 300 feet in from the portal. Drifts from this level extend along the north and middle ore beds.

The upper adit, which is at an elevation of 1808 feet, was driven along the middle ore bed in a northwest direction. Parallel drifts along the north and south ore beds are connected to the adit crosscuts. There are approximately 1,000 feet of underground workings.

Four men were employed at the mine by the Lone Tree Mining Company.

Fabian Mine. Location: sec. 2, T. 4 S., R. 4 E., M.D.M., about 2000 feet northwest of the Ladd mine. Ownership: P. J. Connolly, P. O. Box 811, Tracy, California, leased by Mark C. Lake of San Francisco.

The Fabian manganese deposit is a continuation of the Ladd ore body and the mine was operated contemporaneously with the Ladd mine. The production of the Fabian mine is not known, but it is probably on the order of 2,000 tons (Trask and others, 1950, p. 222).

The ore body, which trends northwest, is composed of massive manganese oxide in the upper levels, and rhodochrosite and bementite in the lower levels. The ore body is about 200 feet long and as much as 8 feet thick. Reserves are estimated to be 5,000 tons of primary carbonate and bementite ore (Trask and others, 1950, p. 222).

The mine contains two levels from which ore has been stoped. At the present time, the mine is flooded.

Ladd Mine. Location: secs. 2 and 11, T. 4 S., R. 4 S., M. D. M., 13 miles by road south of Tracy. Ownership: P. J. Connolly, P. O. Box 811, Tracy, California. Leased by Mark C. Lake, San Francisco and sub-leased by Teekay Mines, Inc., a subsidiary of the Taylor-Knapp Company, Box FF, Philipsburg, Montana. C. P. Knaebel is vice president and general manager of operations, Hugh Engle is mining engineer, Jesse Wilson is mill foreman, and Rupert Mock is mine foreman.

The Ladd mine contains the largest known reserves of manganese ore in California. At the present time, between 100 and 150 tons of ore per day are being produced at the mine. The ore is treated in a recently erected concentrating plant. The battery-grade manganese oxide produced is shipped by railroad to eastern markets.

The mine was first operated in 1867 by A. S. Ladd. In 1874, the mine was sold to Justinian Caire, who operated it intermittently until about 1895 (Trask and others, 1950, p. 223). It was purchased in 1915 by the Providence Exploration Company and operated during World War I, during which time about 10,000 tons of ore was produced. The mine was idle after 1919 (Trask and others, 1950, p. 223).

Between August, 1940 and June, 1941, the U. S. Geological Survey mapped the geology of the Ladd mine and the surrounding area in detail. Also during this time the U. S. Bureau of Mines re-opened the mine and carried on exploration by means of cross-cuts and diamond drilling (Trask and others, 1950, p. 223). The results of this work were published in California Division of Mines Bulletins 125 and 152.

In 1950, the Taylor-Knapp Company sub-leased the mine and began open-pit mining operations for the production of manganese ore for use in the battery industry. A concentrating plant was erected in 1951 and the first car of concentrate was shipped to eastern markets in November 1951 (Huttl, 1952, p. 29).

The Ladd mine is in a northwest-trending belt of Franciscan rocks. There are two ore bodies, called the east and west ore bodies. Most of the ore produced from the deposit has come from the east ore body (Trask and others, 1950, p. 223). The deposit strikes northwest and dips an average of 50° SW. It has been folded into several moderately compressed folds whose axes pitch about 30° NW.

Both ore bodies occur in a 600-foot wide belt of rhythmically bedded chert in sandstone and shale. Strike of the ore bodies is parallel to that of the chert beds. The east or main ore body is 50 feet above the base of

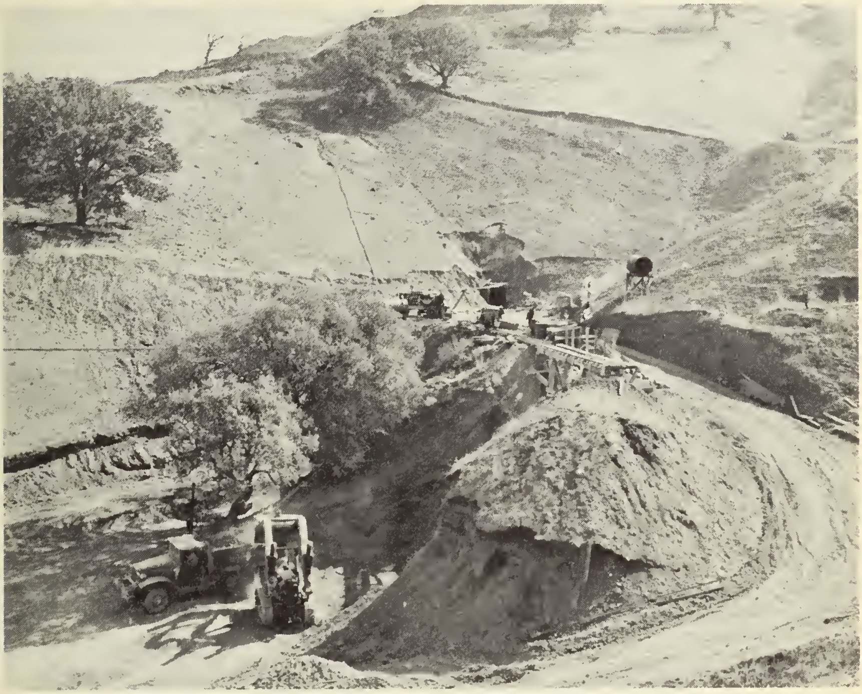

FIGURE 6. The Ladd manganese mine showing the middle adit portal, surface cuts, and ore being loaded for shipment to the mill.

the chert. This ore bed is underlain by a hard massive zone of chert 5 feet thick, which has been an aid in tracing the footwall of the ore in mining operations. The ore body is overlain by thin-bedded red chert overlain by the white chert that contains the west ore body. Above the west ore body is a thick section of red chert. The chert beds associated with the ore vary considerably in thickness and in lithology (Trask and others, 1950, p. 224).

Ore in the east body above the lower level consists of a mixture of pyrolusite (MnO_2) and psilomelane, (barium-bearing hydrous manganese oxide) while below the lower level, it consists of disseminated and massive gray rhodochrosite ($MnCO_3$) and bementite (hydrous manganese silicate). In general, the grade of ore becomes progressively lower upward, at the top grading into manganiferous chert containing only a little manganese. Ore in this body is confined almost entirely to stratigraphic zones. It is cut by a network of quartz and rhodochrosite veins (Trask and others, 1950, p. 224). Only manganese oxide minerals are in the west ore body. The ore is both massive and disseminated.

The main ore bed has been explored for 800 feet along its length and about 350 feet in depth. No mineable ore was encountered by U. S. Bureau of Mines diamond drill holes 75 to 100 feet below the lowest workings (Trask and others, 1950, p. 225). Maximum thickness of disseminated and high-grade ore in the main ore bed is 35 feet, which was measured in the middle tunnel at the intersection of the tunnel with the ore bed. Maximum thickness in the upper level is 25 feet while the maximum thickness of the outcrop is 30 to 35 feet.

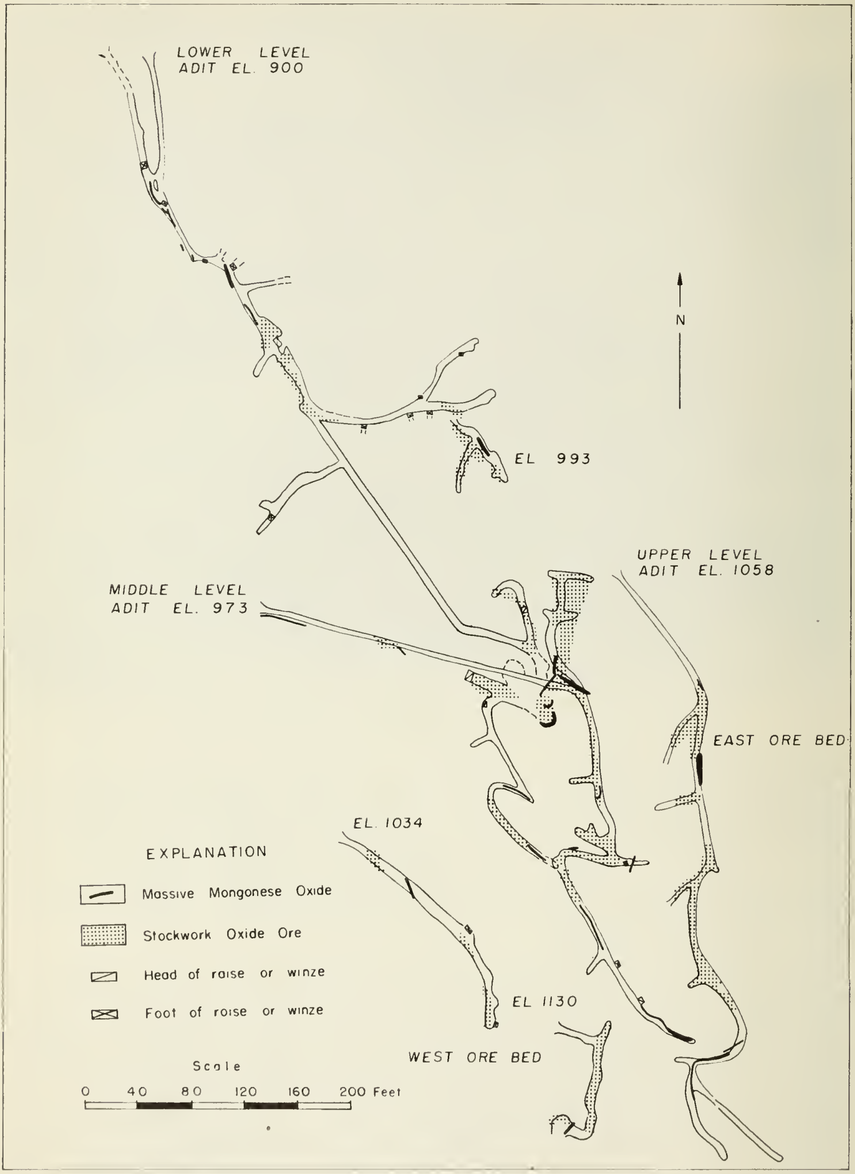
LOWER LEVEL
ADIT EL. 900
N
EL 993
UPPER LEVEL
ADIT EL. 1058
MIDDLE LEVEL
ADIT EL. 973
EAST ORE BED
EL. 1034
EXPLANATION
Massive Manganese Oxide
Stockwork Oxide Ore
Head of raise or winze
Foot of raise or winze
EL 1130
WEST ORE BED
Scale
0 40 80 120 160 200 Feet

FIGURE 7. Map of underground workings of the Ladd manganese mine showing the ore bodies. *After Trask and others, 1950.*

There are three principal faults in the Ladd mine, the Ladd, Steep and Flat faults. The main ore body between the Ladd fault, 300 feet south of the main portal, and the Steep fault, 100 feet south of the Ladd, is displaced 75 to 200 feet to the west. In the upper part of the mine, the rocks are offset 50 feet along the low-angle Flat fault. There are several other smaller faults, along which the rocks have been displaced for short distances.

In 1950, reserves of the Ladd mine were estimated to be 190,000 short tons of oxide ore containing 20 percent manganese and 10,000 tons of carbonate and bementite ore averaging 20 percent manganese (Trask and others, 1950, p. 225). Only high-grade oxide ore had been mined in the past.

Nearly all of the older workings are underground. The main or east ore body is developed by three southeast-extending adits, the lower or Spring level adit, the middle or Red level adit, and the upper level adit. The lower level is at an elevation of about 920 feet, the middle level is 70 to 75 feet above the lower level and the upper level is around 80 feet above the middle level. The ''winze'' level, about 30 feet below the lower level, is now under water. The levels are connected by raises and numerous stopes. This ore body is also accessible by three inclined shafts in the southeastern part of the workings. The west ore body is developed by a southeast-extending adit, the portal of which is at an elevation of 1034 feet. Little timbering is required and nearly all of the workings are open.

When mining operations of the Teekay Company began in 1950, production was from a surface cut at the widest part of the east ore body near the crest of the hill. Mining was done with a power shovel across a 20-foot width and a 30-foot face. Since then a second bench about 125 feet down the slope has been cut, and now extends in a southwest direction and has a 60-foot face.

As surface operations progressed, the principal underground workings, including many of the old raises, were rehabilitated. The lower and middle adit levels were reopened and are now the main haulageways. Underground production in 1953 was from a sub-level stope being driven north from a raise connecting the middle and upper levels 200 feet south of the middle adit portal, and from raises connecting the lower and middle levels. Because of the numerous small faults which offset the ore for small distances, both sub-level and shrinkage methods are employed. In 1953, about half of the total production was from underground workings. The ore is trucked 9 miles to the Teekay Mines, Inc. concentrating plant near the mouth of Corral Hollow Canyon about 4 miles south of Tracy.

Enough ore is stockpiled at the concentrating plant to insure operations for several days. Mill heads range from 25 to 33 percent manganese oxide. Approximately 100 tons of crude ore per day are treated at the mill (Knaebel, C. P., personal communication, 1953).

Concentration at the mill is by dry magnetic separation and wet tabling. Ore is taken from the stockpile by a slusher scraper and delivered to a primary jaw crusher. The crushed ore is transferred by belt conveyor to a bin and then to a double-deck vibrating screen. The minus 0.078-inch material from this screen discharges to a second double-deck vibrating screen, while oversize is sent to cone crushers and then back to the first screen.

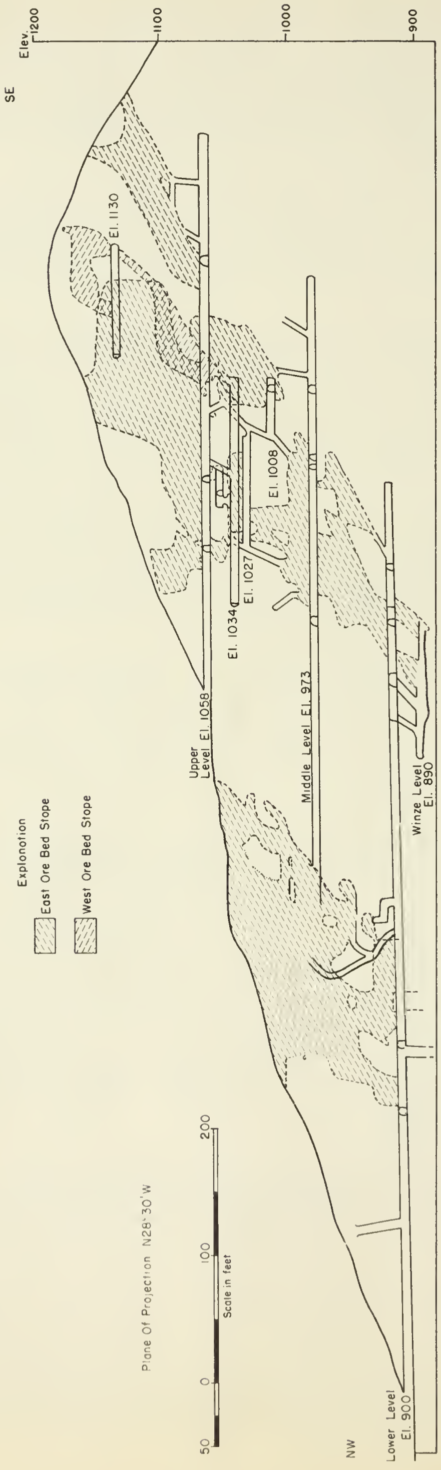
Elev.
1200
1100
1000
900
SE
NW
El. 1130
El. 1008
El. 1027
El. 1034
Upper Level El. 1058
Middle Level El. 973
Winze Level El. 890
Lower Level El. 900
Explanation
East Ore Bed Stope
West Ore Bed Stope
Plane Of Projection N28°30'W
Scale in feet
50
0
100
200

FIGURE 8. Vertical projection of the Ladd manganese mine showing stoped areas. *After Trask and others, 1950.*

From the second screen, minus 0.078- by plus 0.053-inch material is conveyed to a Weatherill-type magnetic separator and minus 0.053- by plus 0.021-inch material is conveyed to two other Weatherill-type magnetic separators. Minus 0.021-inch material is sent to a Deister table.

The dry rough concentrate from the magnetic separators goes to Deister tables, after which it is sent to a drag dewaterer. Middlings go to a Straub ball mill for regrinding. Discharge from the ball mill goes to a 2-cell hydraulic classifier. Fines from the classifier go to Deister tables; sands are sent back to the ball mill.

All table concentrates are dried in a rotary drier and stored in bins. Two battery-grade products, one containing 52 and one 62 percent manganese oxide, are produced. Most of the dried material is shipped in bulk by railroad. The company has a chemical laboratory at the mill which maintains close control of the quality of all material by continuous sampling of the mill heads, the material from the magnetic separators, and the table concentrates.

Twelve men work three shifts at the mill and twelve men work two shifts at the mine.

Mahoney (Doak, Johnson) Mine. Location: sec. 11, T. 4 S., R. 4 E., M. D. M., ½ mile southeast of the Ladd mine and 10 miles southwest of Tracy. Ownership: M. R. Chaves, Rt. 2, Box 408, Tracy, California.

The Mahoney manganese mine was opened in 1918 by R. G. Mahoney and J. W. Bender; however, there was no recorded production at that time (Trask and others, 1950, p. 226). In November, 1942, the mine was leased on a royalty basis by the Johnson Manganese Mining Company, A. W. V. Johnson, president. Production began in 1943 and continued until 1945. The ore was shipped to the Metals Reserve stockpile in Tracy, California. The mine has been idle since 1945. The following production figures were supplied for the Mahoney mine by T. A. C. Bruce, 255 California Street, San Francisco:

Year	Long tons	Mn content	Value
1943	878	36 to 51%	$32,146.56
1944	778	35 to 43%	19,919.48
1945	101	37 to 48%	3,393.75

There are two lenticular ore bodies at the Mahoney mine that occur near the base of a thick lens of Franciscan chert, approximately in the same stratigraphic position as the ore bodies in the Ladd mine (Trask and others, 1950, p. 226). The ore consists of black manganese oxide in a siliceous matrix. Primary ore from which the oxides are derived is not exposed in the mine.

The north or No. 1 ore body is over 60 feet long, 8 to 10 feet thick and extends 30 feet along the dip. The largest production was from this body near its intersection by the main adit (Bruce, T. A. C., personal communication, 1953). Strike of this ore bed ranges from N. 30° W. to N. 45° W. and dip ranges from 60° NE. at the southeast end to 20° NE. at the northwest end.

The south or No. 2 ore body is parallel to and 25 feet southwest of the No. 1 bed in the open cuts but about 70 feet to the southwest in the lower adit level. This ore body is 5 to 10 feet thick, about 60 feet long, and has been stoped about 50 feet along its dip.

The mine is developed by surface cuts and two adits. The upper adit was originally opened in 1918 while the lower or main adit was

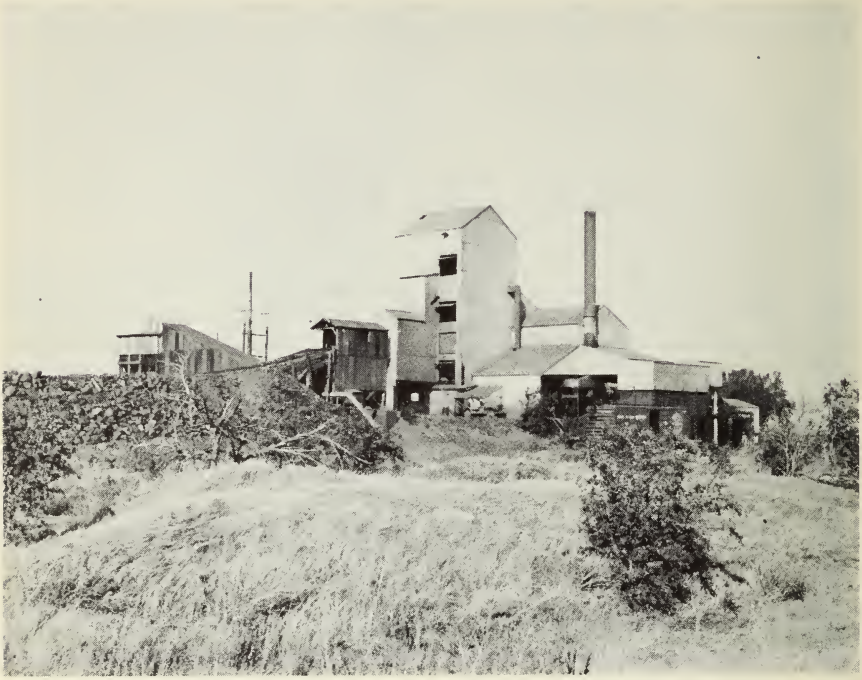

FIGURE 9. Teekay Mines, Inc., manganese mill showing ore stockpile and shipping platform.

developed by the Johnson Company in the '40's. (Bruce, T. A. C., personal communication, 1953). There are approximately 1000 feet of underground workings.

The ore was hand trammed through the adits to a loading bin, from which it was trucked to the U. S. government stockpile at Tracy. Five men were employed at the mine by the Johnson Company.

Natural Gas

In 1951, the 5,465,038 thousand cubic feet of natural gas that was produced from San Joaquin County fields and marketed sold for $1,027,427. Most of this gas came from the McDonald Island field, second largest gas field in northern California, exceeded in size by the Rio Vista field only. Not all of the McDonald Island gas was sold, however; about half of it was used as fuel at the Richmond Oil Refinery by the Standard Oil Company of California, and is not represented by a market value in the production statistics.

All of five natural dry gas fields and part of two others lie within San Joaquin County; except for McDonald Island, all are small fields with small estimated reserves.

As of December 31, 1952, there were more than 20 producing natural gas wells in the county (Bush, 1952b, 32-33). Total proved productive acreage in the county as of that date was 4,125. Natural gas production for 1952 of the individual fields in San Joaquin County in thousands of cubic feet was as follows:

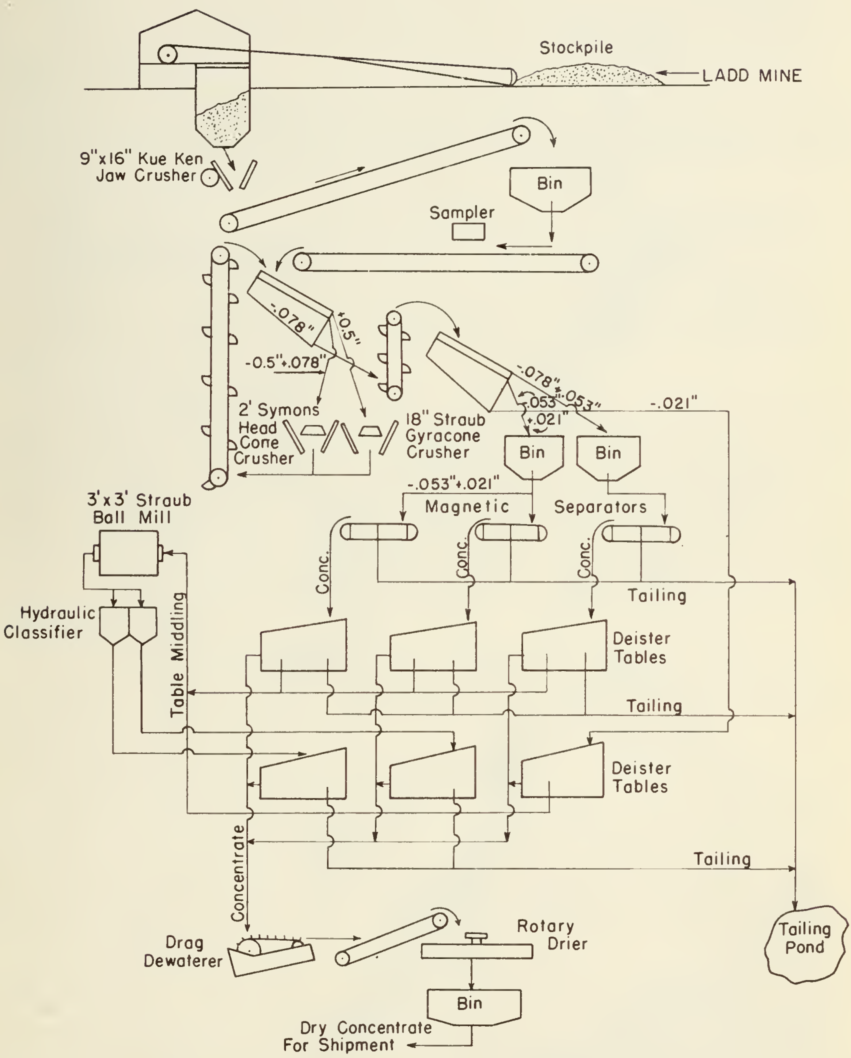
Stockpile
LADD MINE
9"x16" Kue Ken Jaw Crusher
Bin
Sampler
-.078"
+0.5"
-0.5"+.078"
2' Symons Head Cone Crusher
18" Straub Gyracone Crusher
-.078"+.053"
+.053"
+.021"
-.021"
Bin
Bin
-.053"+.021"
Magnetic Separators
3'x3' Straub Ball Mill
Hydraulic Classifier
Table Middling
Conc.
Conc.
Conc.
Tailing
Deister Tables
Tailing
Deister Tables
Concentrate
Tailing
Drag Dewaterer
Rotary Drier
Tailing Pond
Bin
Dry Concentrate For Shipment

FIGURE 10. Mill flow sheet of Teekay Mines, Inc.

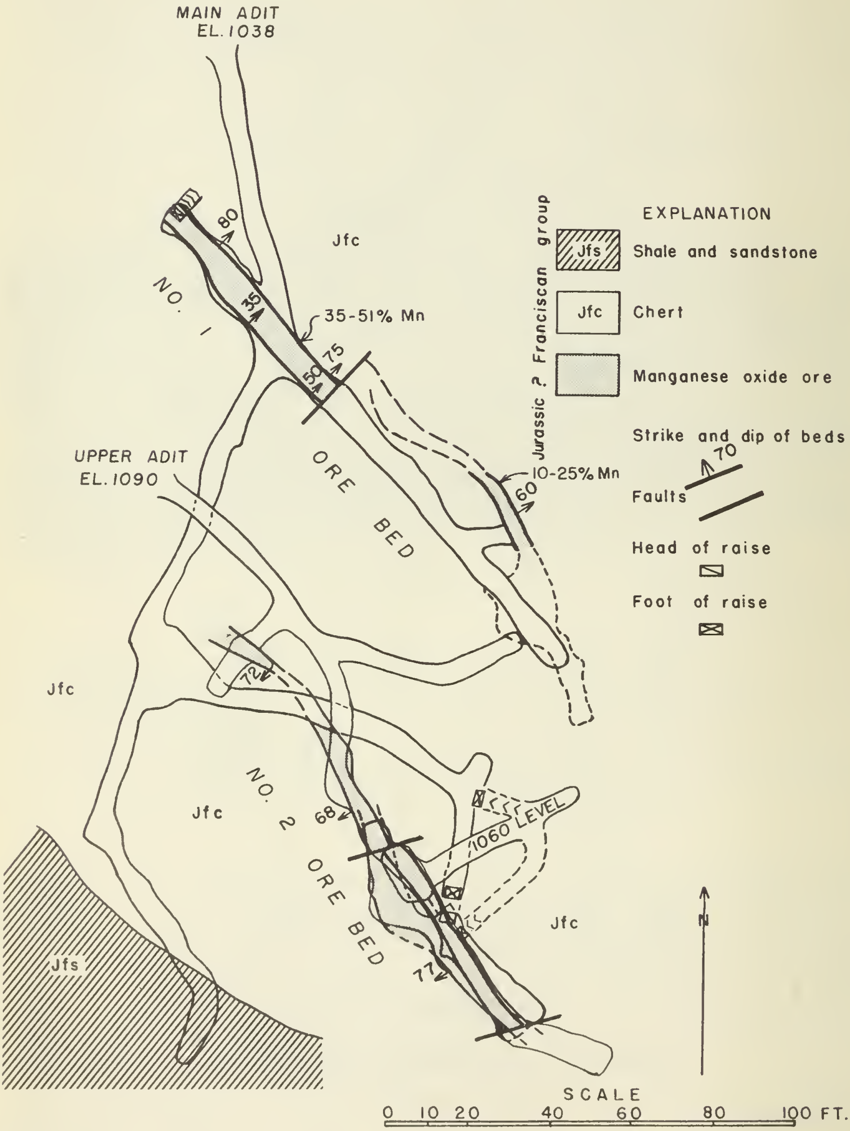
MAIN ADIT
EL. 1038
UPPER ADIT
EL. 1090
NO. 1
ORE BED
NO. 2
ORE BED
35-51% Mn
10-25% Mn
1060 LEVEL
80
35
50
75
60
72
68
77
Jfc
Jfs
N
EXPLANATION
Jurassic ? Franciscan group
Jfs Shale and sandstone
Jfc Chert
Manganese oxide ore
Strike and dip of beds
70
Faults
Head of raise
Foot of raise
SCALE
0 10 20 40 60 80 100 FT.

FIGURE 11. Map of geology and underground workings of the Mahoney manganese mine. *Modified after Trask and others, 1950.*

Galt	63,329
Lodi	432,188
McDonald Island	5,067,874
Roberts Island	353,669
Thornton *	2,591,957
Tracy	285,712
Vernalis †	197,195

* Includes Sacramento County.
† Includes Stanislaus County.

Estimated natural gas reserves of individual fields in San Joaquin County, in thousands of cubic feet, as of January 1, 1953 (Bush, 1952, pp. 39-40), was as follows:

Galt	________
Lodi	11,462,331
McDonald Island	71,772,361
Roberts Island	________
Thornton *	8,669,770
Tracy	9,149,515
Vernalis †	4,684,706

* Includes Sacramento County.
† Includes Stanislaus County.

The first natural gas well in San Joaquin County, perhaps in California, was the famous Court House well in Stockton, which was drilled during the period of 1854-1855. In 1886, the California Well Company of Stockton was organized to produce natural gas in the San Joaquin Valley (Stalder, 1943, p. 79). In 1915, the Western States Gas and Electric Company had 11 operating wells which produced 290,000 cubic feet per day (Lowell, 1915, p. 613). These early natural gas wells in Stockton were relatively shallow with depths ranging from 1100 to 3000 feet.

In 1935, the Tracy gas field was discovered as a result of a seismographic survey (Beckwith, 1943, p. 586). Since then there has been an intensive search for additional natural gas reserves not only in the county but also in much of the rest of northern California.

Structural or stratigraphic traps necessary for the accumulation of commercial quantities of natural gas in San Joaquin County lie beneath the alluvium of the valley floor and have little or no surface evidence; therefore, exploration is done by geophysical methods followed by the drilling of exploratory wells in the most favorable locations. Unproductive exploratory or wildcat wells drilled outside of the gas fields in San Joaquin County are listed in table 2.

Galt Field. The Galt gas field, a northwest-trending anticlinal dome which is located in sections 1 and 12, T. 4 N., R. 6 E. and sections 6 and 7, T. 4 N., R. 7 E., M. D. M., southeast of the town of Galt, was discovered in April, 1943 with the completion of Bankline Community 1-1 by the Bankline Oil Company; this well is now Amerada Petroleum Corporation No. Community-1. Production is from the Nortonville (upper Eocene) (Pierce, 1952, p. 86). Although this is the only well in the field, it is a consistent producer. The log of this well is as follows (Clark and others, 1951):

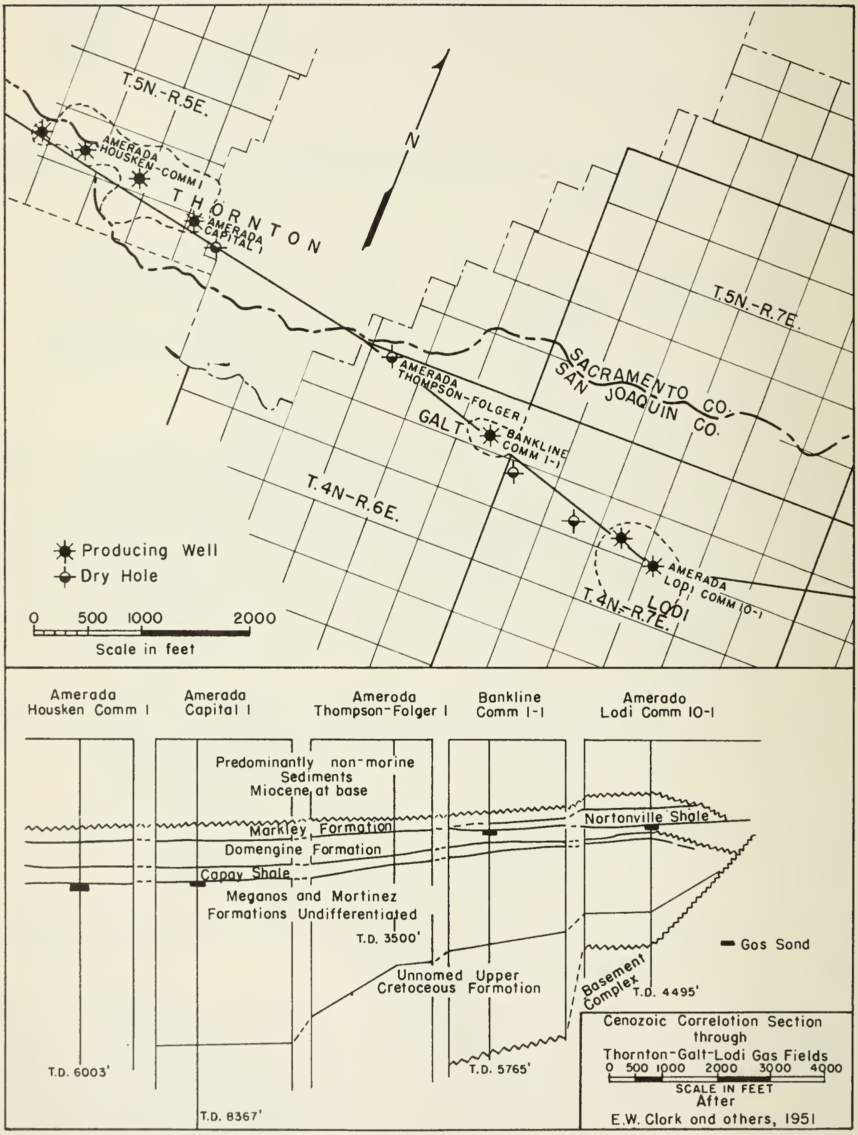
T.5N.-R.5E.
AMERADA HOUSKEN-COMM 1
THORNTON
AMERADA CAPITAL 1
N
T.5N.-R.7E.
SACRAMENTO CO.
SAN JOAQUIN CO.
AMERADA THOMPSON-FOLGER 1
GALT
BANKLINE COMM 1-1
T.4N-R.6E.
AMERADA LODI COMM 10-1
LODI
T.4N.-R.7E.
Producing Well
Dry Hole
0 500 1000 2000
Scale in feet
Amerada Housken Comm 1
Amerada Capital 1
Amerada Thompson-Folger 1
Bankline Comm 1-1
Amerada Lodi Comm 10-1
Predominantly non-marine Sediments Miocene at base
Markley Formation
Nortonville Shale
Domengine Formation
Capay Shale
Meganos and Martinez Formations Undifferentiated
T.D. 3500'
Unnamed Upper Cretaceous Formation
Basement Complex
T.D. 4495'
Gas Sand
T.D. 6003'
T.D. 8367'
T.D. 5765'
Cenozoic Correlation Section through Thornton-Galt-Lodi Gas Fields
0 500 1000 2000 3000 4000
SCALE IN FEET
After E.W. Clark and others, 1951

FIGURE 12.

Depth in feet	Formations
0-2200	Non-marine sediments
2245-2345	Nortonville
2345-2588	Domengine
2588-2750	Capay
2750-4448	Undifferentiated Meganos and Martinez
4448-5700	Cretaceous
5700-5765	Dark gray-green schist

Lodi Field. The Lodi gas field, a northwest-trending anticlinal dome 3 miles northeast of Lodi, was discovered in 1943 with the completion of Amerada Petroleum Corporation Lodi Community 9-1. The indicated potential was 7,222,000 cubic feet. Commercial gas deliveries from the field began in October, 1946 (Walling, 1947, p. 70). Seven wells have been drilled in this field, four of which were producers; three were failures.

Production is from the middle Eocene Domengine formation. The top of this formation ranges from 2000 to 2285 feet in depth in the field.

The following is a list of wells in the Lodi gas field (Clark and others, 1951):

T.	R.	S.	Name of company and well	Date completed	Total depth in feet	Geology
4N	7E	9	Amerada Petroleum Corporation—Lodi Community 9-1	4-43	4471	Top Nortonville 2240′
4N	7E	10	Amerada Petroleum Corporation—Lodi Community 10-1	6-43	4495	Top Markley 1800′, top Nortonville 2000′, top Domengine 2300′, top Capay 2450′, top Meganos 2545′, top Cretaceous 3900′, top basement (porphyritic diabase) 4486′
4N	7E	16	Amerada Petroleum Corporation—Lodi Community 16-1	7-43	2700	Top Nortonville 2285′
4N	7E	15	Amerada Petroleum Corporation—Lodi Community 15-1	8-43	2700	Top Nortonville 2280′

McDonald Island Field. The most productive gas field in San Joaquin County is the McDonald Island field located in T. 2 N., R. 4 E., and T. 2 N., R. 5 E., M. D. M., on McDonald and Roberts Islands, 10 miles northwest of Stockton in the delta region. This field was discovered in 1936 as a result of a reflection seismograph survey by the Standard Oil Company of California (Knox, 1943, p. 588). McDonald Island Farms No. 1 was completed in June, 1936 with an initial flow of 26,000 cubic feet of gas through a $\frac{3}{4}$-inch orifice. Since then, 13 other wells have been drilled. In 1952, there were 11 producing wells and one shut-in.

Structurally, the field is a northwest-trending anticlinal dome. The McDonald Island sand (Paleocene) is the producing zone. This sand lies directly beneath the Capay shale in the western and central por-

Table 2. Exploratory holes drilled outside of gas fields in San Joaquin County to January 1, 1953.

(Oakeshott, Braun, Jennings, and Wells, 1952), (Munger, 1951), and (Munger, 1952).

Map number	T.	R.	Sec.	Company and well	Date started	Year completed or abandoned	Depth in feet	Geology at bottom
1	5N	5E	29	Allison and Prestridge Dinelli 1	1951	1952	4070	Top Nortonville 2880′, top Capay 3206′
2	5N	5E	32	Amerada Pet. Corp., Blossom Community 1	12–43	1943	3592	Eocene
3	4N	8E	7	Alliance Oil Co., No. 1	7–23	1925	900	Cretaceous
4	4N	7E	4	Bankline Oil Co., Community 3-1	5–43	1943	3638	Eocene
5	4N	7E	7	Amerada Pet. Corp., Comm. 7-1	7–43	1943	2900	Eocene
6	4N	7E	7	Union Oil Co., Union-Brazos-Grussendorf	1	1952	4804	
7	4N	7E	8	Amerada Pet. Corp., Comm. 8-1	4–43	1943	3000	Eocene
8	4N	7E	12	Pacific Pet. Producers, No. 1	1932	----	1975	Cretaceous
9	4N	7E	22	Bankline Oil Co., Comm. 22 A-1	6–43	1943	2725	Eocene
10	4N	6E	3	Amerada Pet., Thompson-Folger 1	9–43	1943	3500	Eocene
11	4N	6E	12	Bankline Oil Co., Community 2-1	5–43	1943	5702	Basement
12	4N	4E	13	Shell Oil Co., Staten Island 2	12–45	1946	4502	Paleocene
13	4N	4E	22	Brazos Oil & Gas Co., Brown 1	6–49	1949	5500	B-1A zone (Nortonville) 3482′, Domengine 3707′, top Capay 4247′, top Midland 4395′
14	4N	4E	25	Amerada Corp., Powell Core Hole 1	----	1952	4821	
15	4N	4E	33	Brazos Oil & Gas, George H. Jensen A-1	----	1952	4567	Midland sand
16	4N	4E	35	Shell Oil Co., Staten Island 1	9–45	1945	6500	Cretaceous
17	3N	5E	7	Amerada Corp., Atkins-Kroll-Core Hole 1	----	1952	5502	
18	3N	5E	15	Amerada Corp., Coldani Core Hole 1	----	1952	4912	
19	3N	5E	29	Amerada Pet. Corp., G & P Core Hole 1	----	1952	5460	
20	3N	6E	29	Honolulu Oil Corp., Brack Comm. R-1	2–45	1945	5004	Cretaceous
21	2N	8E	2	Amerada Pet. Corp., Martenet 25-2	4–48	1948	4319	Basement
22	2N	5E	9	Shell Oil Co., Pacific States 1	4–49	1949	5550	Eocene
23	2N	4E	5	Standard Oil Co. of Calif., Mandeville Island 1	4–44	1944	5600	Paleocene
24	2N	4E	16	Shell Oil, Mandeville Island 1	8–50	1950	6983	Cretaceous
25	2N	4E	26	Rawn, William L., Mildred Island 1	----	1951	5801	
26	1N	9E	6	Richfield Corp., East Stockton 2	3–44	1944	6376	Cretaceous
27	1N	8E	5	Richfield Corp., East Stockton 1	11–43	1944	8544	Cretaceous
28	1N	7E	19	Standard Oil Co. of Calif., Fairoaks Community 1	4–44	1944	6500	Cretaceous
29	1N	6E	2	Pacific Gas & Elec. Co., No. 4	----	1932	1720	Miocene?
30	1N	6E	2	Pacific Gas & Elec. Co., No. 5	----	1936	2071	Miocene?
31	1N	6E	2	Pacific Gas & Elec. Co., No. 10	----	1932	2006	Miocene?

32	1N	6E	3	Pacific Gas & Elec. Co., Citizens 1	----	1932	2000	Miocene?
33	1N	6E	3	Pacific Gas & Elec. Co., Citizens 2	----	1936	1850	Miocene?
34	1N	6E	7	Utilities Pet. Corp., Rough and Ready Island 1	----	1939	5721	Eocene
35	1N	6E	7	Utilities Pet. Corp., Rough and Ready 1	9–39	1939	5715	Cretaceous
36	1N	6E	10	Pacific Gas & Elec. Co., No. 3	----	1932	1890	Miocene?
37	1N	6E	10	Pacific Gas & Elec. Co., No. 7	----	1936	2230	Miocene?
38	1N	6E	10	Pacific Gas & Elec. Co., Stockton 1	----	1932	1702	Miocene?
39	1N	6E	12	Pacific Gas & Elec. Co., No. 6	----	1936	1810	Miocene?
40	1N	5E	4	Standard Oil Co., West Coast Life 2-1	1–42	1942	5306	Eocene
41	1N	5E	15	Standard Oil Co., Holt Comm. 1	8–43	1943	5319	Eocene
42	1N	5E	21	Madison, Lemos & Mattos, Budd 1	----	1932	1040	Cretaceous
43	1N	5E	24	Standard Oil Co., Woods Comm. 1	----	1937	7014?	Cretaceous
44	1N	5E	36	Standard Oil Co., Roberts Island Comm. 1	9–43	1943	5262	Eocene
45	1N	4E	1	M. R & M. Syndicate, Pacific States 2	7–46	1946	5409	Paleocene
46	1N	4E	3	Ohio Oil Co., Pacific States 1	3–46	1946	5826	Paleocene
47	1N	4E	21	Universal Consolidated Oil Co., Pacific States 1	11–48	1948	5950	McDonald Island ss5726′
48	1N	4E	33	Amerada Pet. Corp., Borden 1	9–46	1946	6000	Paleocene
49	1S	4E	10	Amerada Pet. Corp., Calif. Packing Corp. 1	10–47	1947	6000	Eocene
50	1S	4E	26	Ohio Oil Co., Wm. C. Ferguson 1	4–49	1949	5449	Markley sh 4400′, Nortonville sh 4730′ Domengine white ss 4972′, Capay sh 5276′, Meganos-McDonald Island ss 5353′
51	1S	6E	6	Ohio Oil Co., Edward W. Avila 1	1–47	1947	4400	Cretaceous
52	1S	6E	8	Texas Co., The, Laurence-Stephan 1	6–37	1937	5839	Cretaceous
53	1S	7E	22	Westates Pet. Corp., Spence 1	3–42	1942	5710	Cretaceous
54	2S	4E	33	Tracy Oil Co.	----	pre-1915	3100	
55	2S	4E	33	Wallenberg, Daisy 1	----	pre-1924		
56	2S	5E	6	Seaboard Oil Co., Hall 1	----	1951	5015	Cretaceous
57	2S	5E	6	Seaboard Oil Co., Mary Simos 1	----	1951	4692	
58	2S	5E	24	Standard Oil Co. of Calif., Gerhart Community 1	4–44	1944	5900	Cretaceous
59	2S	6E	32	Shell Oil Co., Inc., Wright 1	5–45	1945	5321	Cretaceous
60	3S	4E	2	Coast Exploration Co., T.-F-1 1	3–37	1937	3469	Cretaceous
61	3S	4E	24	Milham Exploration Co., Moy 1	8–34	1934	1122	Eocene
62	3S	4E	24	Milham Exploration Co., Moy 2	9–34	1934	4002	Cretaceous
63	3S	6E	14	Union Oil Co., Tracy Land 1	12–31	1932	5511	Cretaceous
64	3S	6E	23	Standard Oil of Calif., Blewett Comm. 3	11–43	1943	5257	Cretaceous
65	4S	5E	5	Milham Exploration Co., Connolly 1	1–34	1934	5800	Cretaceous
66	4S	6E	8	Union Oil Co., Schnabel 36-8	----	1952	5288	

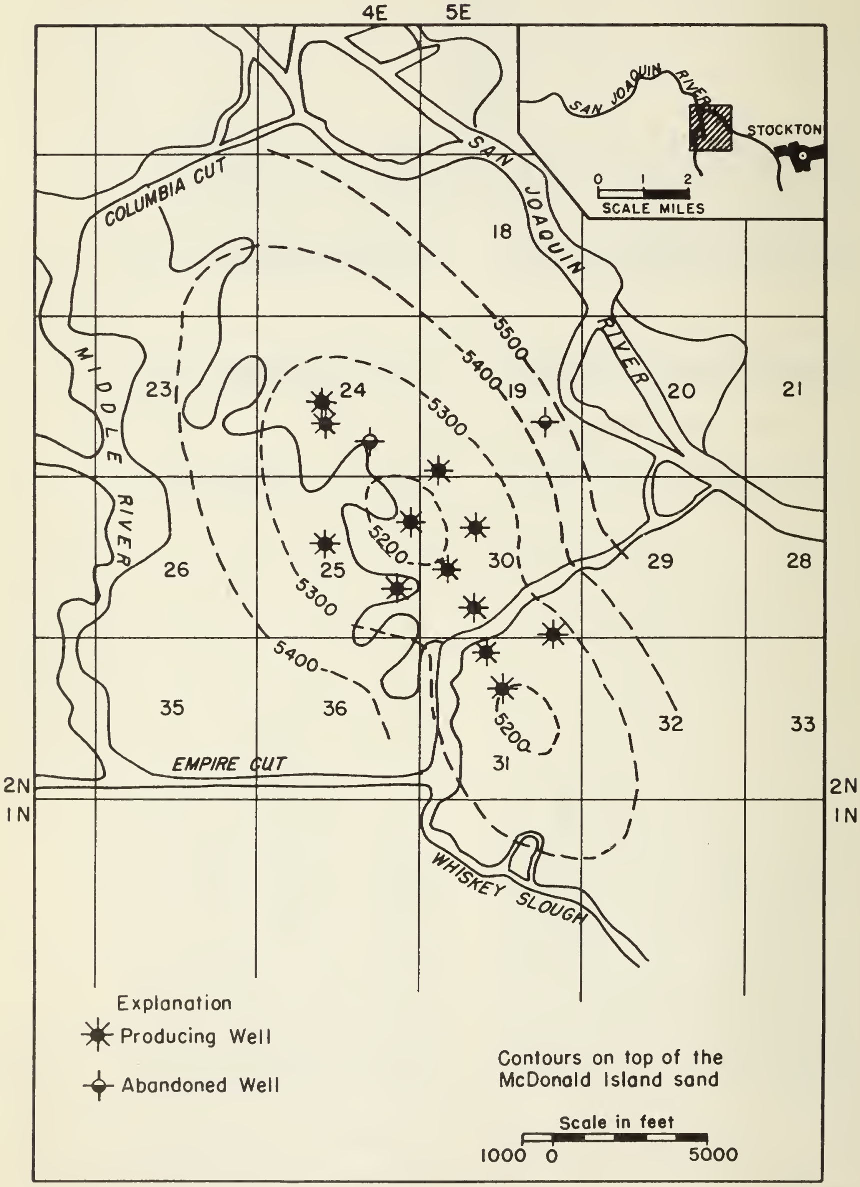
4E
5E
SAN JOAQUIN RIVER
STOCKTON
0 1 2
SCALE MILES
COLUMBIA CUT
SAN JOAQUIN RIVER
MIDDLE RIVER
EMPIRE CUT
WHISKEY SLOUGH
18
19
20
21
23
24
25
26
28
29
30
31
32
33
35
36
5500
5400
5300
5200
2N
1N
Explanation
Producing Well
Abandoned Well
Contours on top of the McDonald Island sand
Scale in feet
1000 0 5000

FIGURE 13. Structure map of the McDonald Island gas field. *After Knox, 1943.*

tions of the field. In the eastern portion of the field, the Capay overlaps the Martinez shale which in turn lies directly on the McDonald Island sand (Knox, 1943, p. 590). The McDonald Island sand is friable gray sand with interbedded siltstone, shale, and a few carbonaceous streaks. The top of the Cretaceous rocks has been placed at a depth of 6835 feet in the field (Knox, 1943, p. 590).

A log of the McDonald Island Farms No. 1 is as follows (Knox, 1943, p. 588):

Depth in feet	Formation
0-1450	Pleistocene and Pliocene sediments
1470-2772	Mehrten formation
2797-3555	Freshwater Miocene
3570-3846	Brackish water Miocene
3846-3968	Marine Miocene
3968-4208	Markley shale
4224-4973	Domengine sand
4973-5178	Capay shale
5178-5224	McDonald Island sand

The following is a list of wells in the McDonald Island gas field:

T.	R.	S.	Name of company and well.	Date completed	Total depth in feet
2N	4E	25	Standard Oil Co. of California McDonald Island Farms 1	5-36	5227
2N	5E	19	Standard Oil Co. of California McDonald Island Farms 2	Abdn. 12-36	5712
2N	4E	24	Standard Oil Co. of California McDonald Island Farms 3	5-37	5337
2N	5E	30	Standard Oil Co. of California McDonald Island Farms 4	11-49	5278
2N	5E	30	Standard Oil Co. of California McDonald Island Farms 5	10-49	5283
2N	5E	30	Standard Oil Co. of California McDonald Island Farms 6	11-49	5279
2N	5E	19	Standard Oil Co. of California McDonald Island Farms 7	11-49	5278
2N	4E	24	Standard Oil Co. of California McDonald Island Farms 8	Abdn. 12-49	5400
2N	4E	25	Standard Oil Co. of California Welyl-Zuckerman No. 1	8-38	5273
2N	4E	25	Standard Oil Co. of California Welyl-Zuckerman No. 2	3-38	8810
2N	4E	25	Standard Oil Co. of California Welyl-Zuckerman No. 3	11-49	5279
2N	5E	31	Standard Oil Co. of California Mabry Community No. 1	10-36	5312
2N	5E	31	Standard Oil Co. of California Mabry Community No. 2	2-41	5285
2N	5E	31	Standard Oil Co. of California Tilden Community No. 1	2-37	5312

Roberts Island Field. The Roberts Island gas field is in section 23, T. 1 N., R. 5 E., M. D. M. 5 miles southwest of Stockton. In was discovered in August, 1942 by the Standard Oil Company of California with completion of Woods Community No. 2-1. Initial flow was 5,600,-

000 cubic feet through a $\frac{3}{8}$-inch orifice. Although this is the only well in the field, it has been a consistent producer since its discovery. The producing zone is the McDonald Island sand (Paleocene?).

Thornton Field. The Thornton field was discovered in 1943 with the completion of Housken Community No. 1 by the Amerada Petroleum Corporation. The field is a nearly east-trending anticlinal dome in both Sacramento and San Joaquin Counties near the town of Thornton. Commercial gas deliveries began in December, 1946, (Walling, 1947, p. 71).

Production is from the Capay or Capital sand (lower Eocene). In 1952, there were 7 producing and 3 shut-in wells.

The following is a list of wells in the Thornton gas field in San Joaquin County (Clark and others, 1951):

T.	R.	S.	Name of company and well	Date completed	Total depth in feet	Geology
5N	5E	28	Amerada Petroleum Corporation—Amerada Housken Community 1	9-43	6003	Top Markley 2350′, top Domengine 2652′, top Capay 3023′, top Meganos 3292′, top Cretaceous 4950′.
5N	5E	29	Amerada Petroleum Corporation—Amerada McGillivray Community 1	3-44	3500	Top Meganos 3335′.

Tracy Field. The Tracy gas field is in sections 15 and 22, T. 2 S., R. 5 E., M. D. M. in the southwestern portion of the county near Tracy. It was discovered in 1935 by the Amerada Petroleum Corporation by seismic methods. It was the first commercial gas field found in northern California, and the first field to produce gas commercially from Cretaceous sediments (Beckwith, 1943, p. 586).

This field is a northwest-trending anticlinal dome. The field lies in a Cretaceous shelf where Eocene sediments are absent. Wells in this field pass directly from Pliocene sediments through an unconformity into Cretaceous beds. The producing zone is the *Nodosaria spinifera* zone of the Upper Cretaceous Panoche formation (Beckwith, 1943, p. 587). In 1951, there was but one producing well in the field.

The following is a list of wells in the Tracy gas field (Beckwith, 1943, p. 587):

T.	R.	S.	Name of company and well	Date completed	Total depth in feet	Geology
2S	5E	15	Amerada Petroleum Corporation—FDL 1	1-36	9690	Non-marine sediments 0-3477′, top Moreno 3477′, top Panoche 3895′, top gas sand 4005′.
2S	5E	15	Amerada Petroleum Corporation—FDL 2	8-35	4063	Top gas sand 4063′.
2S	5E	15	Amerada Petroleum Corporation—FDL 3	1-36	4029	Top gas sand 4029′.
2S	5E	15	Amerada Petroleum Corporation—FDL 4	2-36	5050	Top gas sand 4050′.
2S	5E	15	Amerada Petroleum Corporation—FDL 5	3-36	6160	Top gas sand 4025′.

2S	5E	22	Amerada Petroleum Corporation—31-22 Tracy	10-35	4133	Top gas sand 4060′.
2S	5E	23	Amerada Petroleum Corporation—11-23 Tracy	Abdn. 12-35	5107	Bottomed in Panoche.
2S	5E	16	Holly Development Co.—Padden No. 1	Abdn. 5-36	4125	Bottomed in Panoche.

Vernalis Field. The Vernalis gas field in southwestern San Joaquin and northwestern Stanislaus Counties east of the town of Vernalis was discovered in December 1940 with the completion of Blewett Community No. 1 by the Standard Oil Company of California. In 1951, there were one producing and one shut-in well.

As in the Tracy field, which lies to the northwest, Eocene sediments are absent and production is from Cretaceous beds. The producing zone is the Blewett sand which is part of the Panoche formation.

The following is a list of wells in the Vernalis gas field:

T.	R.	S.	Name of company and well	Date completed	Total depth in feet
3S	6E	25	Standard Oil Co. of California—Blewett Community 1	1-41	3872
3S	6E	23	Standard Oil Co. of California—Blewett Community 2	Abdn. 11-43	5257
3S	6E	25	Standard Oil Co. of California—Blewett Community 3	5-41	5507

Peat

Although there has been no recorded production of peat, large quantities of it occur in San Joaquin County in the delta of the lower San Joaquin River. Peat is the decomposed, disintegrated vegetal matter, chiefly mosses, tules, and grasses. A deficiency of oxygen during the formative process prevents complete decay so that the carbonaceous matter is preserved. Peat was formed during Recent geologic time.

To the west, near Bethel Island in Contra Costa County, tule peat and peat dirt are produced. The material is processed by sun drying and shredding and then sold as a soil conditioner, or it is compounded with commercial fertilizers and then added to the soil (Braun, 1950, p. 84).

Petroleum

Although there is no recorded production of petroleum in San Joaquin County, slight oil showings were claimed in a well drilled by the Tracy Oil Company prior to 1915 in sec. 33, T. 2 S., R. 4 E., M. D. M. (Huey, 1948, p. 65). This well was drilled to a depth of 3100 feet. Minor amounts of oil were produced many years ago in shallow wells from basal Cierbo sands (upper Miocene) and upper Panoche (Upper Cretaceous) sands on the Hamilton Ranch in Alameda County about 6 miles northwest of Carnegie (Huey, 1948, p. 67).

Platinum

Small amounts of platinum and platinum-group metals have been produced in San Joaquin County as by-products of gold dredging operations. Platinum and platinum-group metals occur as fine grains and small nuggets in stream and river beds associated with the gold in black sands. The metals are recovered in placer gold operations by either hand-panning or jigging the black sand concentrate after the gold has been removed.

Sand and Gravel

Introduction

Sand and gravel has the largest value of all mineral commodities now produced in San Joaquin County. In 1951, 1,866,075 short tons of sand and gravel valued at $1,095,331 was produced in the county. This figure represents approximately 45 percent of the value of the total mineral production for the county for that year. Two plants, which are about 4 miles south of Tracy, the Tracy Rock and Gravel Company and the Kerlinger plant of Pacific Coast Aggregates, Inc., are the largest producers in the county. Other important operations are the Claude C. Wood plant northeast of Clements and the Putnam Sand and Gravel Company plant south of Escalon.

Other large producers in San Joaquin County in recent years, now idle or abandoned, were the Santa Fe Sand and Gravel Company and the Pacific Coast Aggregates, Inc., River Rock plant.

Because of the relative importance of sand and gravel as a mineral commodity in San Joaquin County, each operation is described separately. Recent large operations, which are now abandoned or idle, are also described separately.

From 1913 to 1951, 17,067,025 short tons of sand and gravel valued at $11,340,798 were produced in San Joaquin County. Over half of this production has been since 1945. This is a direct result of the post-World II increase in building and industrial activities in the general area of the county.

The first recorded production of sand and gravel in San Joaquin County was in 1913. Gravel pits, however, were worked prior to that date in the Corral Hollow Canyon area (Aubury, 1906, p. 322). In 1916, the River Rock Gravel Company erected a 2000-ton per day plant in Corral Hollow Canyon (Laizure, 1925, p. 198). In 1925, there were six sand and gravel pits in operation in the county.

Soon after World War II, the two large modern plants south of Tracy were erected. The Kerlinger plant of Pacific Coast Aggregates, Inc. supplied much of the aggregate used in construction of the Delta-Mendota Canal and the Tracy Pumping Plant of the Central Valley Project.

Geology

Sand and gravel deposits occur quite extensively in San Joaquin County. At the present time, terrace, bar, channel, and alluvial fan deposits of Recent age are being exploited. The largest production is from the alluvial fan of Corral Hollow Creek south of Tracy.

The most important deposits in San Joaquin County are in extensive alluvial fans along the eastern flank of the Coast Ranges that have been deposited by northeast-flowing streams. These deposits are many square miles in area and as much as 100 or more feet in depth. The largest are those which have been deposited by Corral Hollow, Lonetree, and Hospital Creeks. These deposits compare favorably with other Coast Range deposits, such as those in the Livermore area, as they contain similar material and two large successful plants are now operating in the Corral Hollow Creek deposit. The Lonetree and

Hospital Creek deposits are undeveloped and exist as possible future sources of aggregate material in the county.

The gravels in these alluvial fan deposits are composed largely of metagraywacke (a dark feldspathic sandstone), chert, and veinlet quartz derived from the Franciscan (Upper Jurassic?) formation. Smaller amounts of Franciscan quartzite metasediments, schist, and basic igneous rock, Panoche (Upper Cretaceous) sandstone, and Tertiary andesite are present. The amount of chert and sandstone present in these deposits increases to the southeast while the amount of andesite decreases.

Less extensive sand and gravel deposits occur in stream terraces, bars, and channels of west-flowing streams in eastern San Joaquin County. Terraces on the north bank of the Stanislaus River and bar and channel deposits of the Mokelumne are the largest deposits in this portion of the county. These deposits have been successfully exploited for nearly 40 years.

The Victor formation (Pleistocene), as mapped by Piper and others in 1939, which is an important source of sand and gravel in the Sacramento area, covers much of eastern San Joaquin County. Only a small amount of sand and gravel in the Bellota area has been produced from this formation in the county.

Deposits in eastern San Joaquin County are composed largely of material derived from Sierra Nevada bedrock. Vein quartz, quartzitic metasediments, greenstone, and granitic rock are the principal rock types present in these deposits. Smaller amounts of schist, basic igneous rock, and Tertiary volcanic rocks are also present. The amount of vein quartz present in these deposits decreases to the south while the amount of Tertiary volcanic rock increases.

The following table shows a pebble count of the rock types in gravel samples taken from deposits on the five principal streams in San Joaquin County.

Table 3. Pebble count of rock types in five gravel deposits in San Joaquin County

EAST SIDE

Rock type	Mokelumne River at Clements	Calaveras River at Bellota	Stanislaus River at Riverbank
Vein quartz	10–25	20–25	2–5
Granitic rock	2–10	tr	15–25
Quartzitic metasediments	20–40	25 ±	20 ±
Greenstone	20–30	30–50	20 ±
Tertiary volcanic rock	2–7	2–4	15–20
Basic igneous rock	–	1–3	1–5
Schist	1	–	1–5

WEST SIDE

Rock type	Corral Hollow Creek at Kerlinger	Hospital Creek east of Vernalis
Feldspathic sandstone	50–75	40–60
Veinlet quartz	10–15	10–20
Chert	10–15	20–30
Basic igneous rock	5–10	1–5
Tertiary andesite	5–10	–
Panoche sandstone	1–5	5–10
Quartzitic metasediments	1	–
Schist	1	–

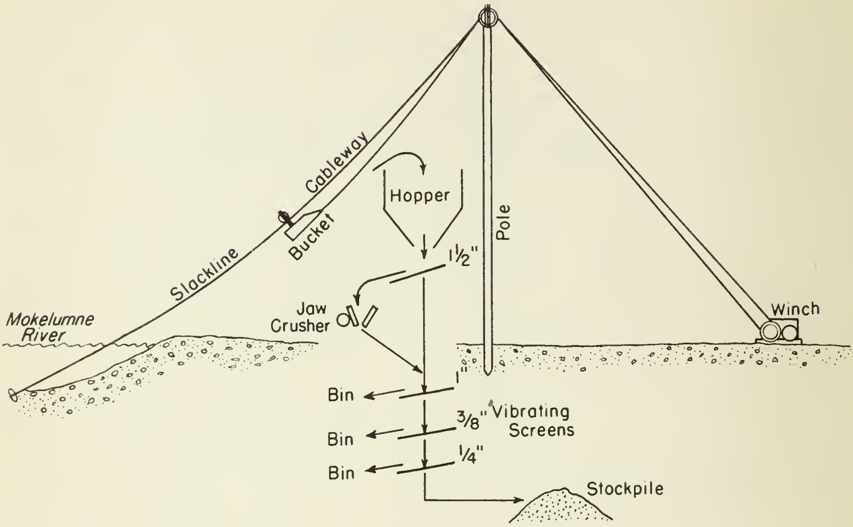

FIGURE 14. Flow sheet of operations at the Clements sand and gravel pit.

Operations

Production of sand, gravel, and crushed rock consists of three main phases of operation: mining or quarrying, classifying, and crushing.

Sand and gravel mining in San Joaquin County is done by open-pit methods. Excavation is done largely by dragline excavators, although two small pits on the Mokelumne River use slackline cableways. Occasionally power shovels and clamshells are used for excavating and loading. Bucket capacities of these different types of equipment range from $\frac{3}{4}$ to 3 cubic yards. At one time, carryall scrapers were used at one large plant, but were abandoned in favor of a dragline. Bottom-dump wagons are used in the large and end-dump trucks are used in the smaller operations to haul excavated material to the aggregate plant, which is a mile or less from the pit.

At the aggregate plant, the raw material is washed, classified, and crushed. The larger plants are divided into separate but integrated units which perform these functions. Belt conveyors are used wherever possible and give these plants much flexibility in operation. Some operators also have separate road rock, hot-mix, and batching plants.

Primary crushing is done with jaw crushers, while secondary crushing is done with cone or gyratory crushers. One operator employs roll crushers. The larger washing plants are equipped with cylindrical scrubbers, and one plant uses a log washer for the removal of vegetal material. Crusher settings and screen sizes in all of the plants are varied to produce the different types of finished material desired.

Clements Pit. Location: sec. 14, T. 4 N., R. 8 E., M. D. M., 1 mile northeast of Clements on the south side of the Mokelumne River. Ownership: A. B. Warner, 2457 E. Flora, Stockton, California.

The Clements gravel pit was opened originally in 1931. It was purchased in 1941 by A. B. Warner who has operated it since that date. Approximately 75 percent of the material produced is trucked to the A. B. Warner batching plant at Martell, Amador County, while the remaining 25 percent is sold locally.

Sand and gravel from a terrace deposit on the south side of the Mokelumne River is bulldozed into the river where it is washed. This material is then dredged from the river using a slackline cableway with a 1¾-yard bucket and dumped into a hopper above the crushing and sizing plant. The material is screened, the portion over 1½ inches in size being sent to a Kue Ken crusher. Undersize and discharge from the crusher drops down to a series of vibrating screens. Four sizes of crushed rock are produced: ¼- by ⅜-inch, ⅜- by 1-inch, 1- by 1½-inch and plus 1½-inch. Sand down to 200-mesh in size is also produced. Five men work at the plant.

Mokelumne Pit. Location: sec. 14, T. 4 N., R. 8 E., M. D. M., 1 mile northeast of Clements on the south side of the Mokelumne River. Ownership: Neil Ellsbury, Clements, California.

This plant produces about 450 cubic yards of sand and gravel per month which is sold locally (Ellsbury, Neil, personal communication, 1953). Mr. Ellsbury purchased the plant early in 1953. Prior to that date, it was operated by P. F. Sivers who had purchased it in 1947. From 1939 until 1945, it was known as the Mokelumne Sand and Gravel Company. In 1946, a small amount of by-product gold was recovered at the plant.

Sand and gravel from the bed of the Mokelumne River are excavated by a slackline cableway with a 1¾-yard bucket. The bucket deposits the material into a hopper above the sizing and washing plant.

From the hopper, the material drops down to a series of vibrating screens and a washer. Undersize from the screens is sent to two rake classifiers which discharge to yard stockpiles. Sizes produced at this plant are 3-inch, 2-inch, 1-inch, ordinary sand, plaster sand, and fine sand. Three men work at the plant.

Pereira Pit. Location: sec. 17, T. 3 S., R. 5 E., M. D. M., 4 miles south of Tracy and ½ mile west of the Tracy Rock and Gravel Company plant.

This sand and gravel operation was started in 1939 and abandoned in 1945. During that time, it was owned and operated by Alfred Pereira, 1410 Holly Drive, Tracy, California. Soon after the operation was shut down, the property was purchased by the Tracy Rock and Gravel Company.

From 1939 until 1942, pit-run sand and gravel were produced. In 1942, a crushing and sizing plant was installed. About 150 tons of finished material per day was produced which was marketed in the Tracy area (Pereira, Alfred, personal communication, 1953).

There were two small pits, each about 2 acres in extent and ranging from 20 to 30 feet in depth. Material was excavated by a ¾-yard power shovel and trucked to the plant. The plant was equipped with an Iowa

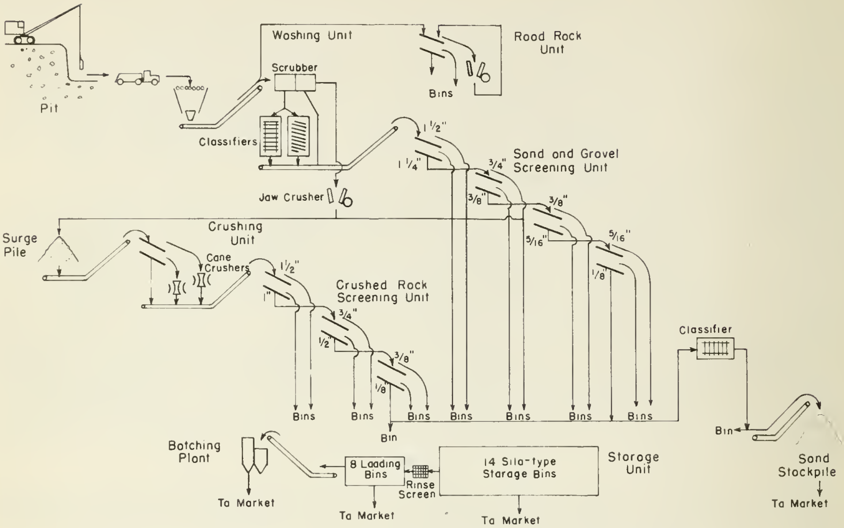
Pit
Washing Unit
Scrubber
Classifiers
Road Rock Unit
Bins
Jaw Crusher
1 1/2"
1 1/4"
3/4"
Sand and Gravel Screening Unit
3/8"
3/8"
5/16"
5/16"
1/8"
Surge Pile
Crushing Unit
Cone Crushers
1 1/2"
1"
Crushed Rock Screening Unit
3/4"
1/2"
3/8"
1/8"
Bins
Bins
Bins
Bins
Bins
Bins
Bins
Bin
Classifier
Bin
Batching Plant
To Market
8 Loading Bins
Rinse Screen
To Market
14 Silo-type Storage Bins
To Market
Storage Unit
Sand Stockpile
To Market

FIGURE 15. Modified flow sheet of the Pacific Coast Aggregates, Inc., Kerlinger sand and gravel plant.

one-piece sizing unit, which consisted of a trommel and a multiple-deck screen, and a jaw crusher. Sand and the finer aggregate sizes were produced. Three men worked at the plant.

Pacific Coast Aggregates, Inc., Kerlinger Plant. Location: sec. 16, T. 3 S., R. 5 E., M. D. M., 4 miles south of Tracy. Ownership: Pacific Coast Aggregates, Inc., 400 Alabama Street, San Francisco, California. E. E. Williams is plant superintendent.

This plant produces standard sizes of sand, gravel, and crushed rock which is largely used in the Stockton-Modesto area. Maximum plant capacity is 450 tons of finished products per hour (Williams, E. E., personal communication, 1953). There is also a 100-cubic yard per hour Noble batching plant at the property.

The plant was placed in operation in 1947 (Lenhart, 1947, p. 70) replacing the old River Rock plant 2 miles to the southwest which had been in operation since 1916 (Laizure, 1925, p. 198).

The pit, nearly a square mile in extent, is located in the alluvial fan deposited by Corral Hollow Creek. In this area the deposit ranges from 100 to 125 feet in thickness (Williams, E. E., personal communication, 1953). A few thin lenses of reddish clay are interbedded with the sands and gravels. The pit is worked in 30-foot benches.

The gravels are excavated with a 3-cubic-yard Bucyrus Erie dragline which loads into 25-ton Woolridge wagons which deliver the material to the plant $\frac{1}{2}$ mile to the north. The wagons discharge through a grizzly to a 200-ton hopper. A compressed air-operated vibrating feeder under the hopper discharges the material to a belt conveyor in a tunnel which feeds the plant.

The material first goes to the primary washing unit, which consists of a 36- by 6-foot cylindrical scrubber with $\frac{3}{8}$-inch and $2\frac{1}{2}$-inch openings and two classifiers, a rake and a triple screw. The minus $\frac{3}{8}$-inch material is split between the two classifiers producing sand which is discharged, along with the minus 2½-plus ⅜-inch scrubber material onto a belt conveyor leading to the sand and gravel screening unit. The rejected plus 2½-inch material from the scrubber is put through 10- by 36-inch jaw crusher and sent by belt conveyor to the crushed rock surge pile.

The sand and gravel screening unit consists of four 5- by 12-foot double deck vibrating screens. The various screen products are dropped through chutes into cylindrical storage bins. Sand, after screening and washing, is sent to a rake classifier for a final washing. Product from this classifier is stored in a bin or conveyed to open storage.

Commercial sizes produced are: 2½- by 1½-inch, 1½- by ¾-inch, ¾- by ⅜-inch, ⅜- by 5/16-inch, 5/16- by ⅛-inch gravel and sands. Gravel sizes above ¾-inch are stored in bins from which the material can be conveyed to the crushing unit as desired for reduction into crushed rock.

The crushing unit consists of two cone crushers which are fed either from the plant or the crushed rock surge pile. About 90 percent is crushed to minus ½-inch. Discharge from the crushers goes to three 5- by 10-foot vibrating screens which produce the following sizes: 1½- by ¾-inch, ¾- by ½-inch, ½- by ⅜-inch, ⅜- by ¼-inch, ¼- by ⅛-inch, ¼- by ⅛-inch and minus ⅛-inch crushed rock and plus ⅜-inch dust crushed mineral aggregate for use in ''hot'' plants. Sizes produced are stored in steel bins. The minus ⅛-inch material is sent to the sand classifier.

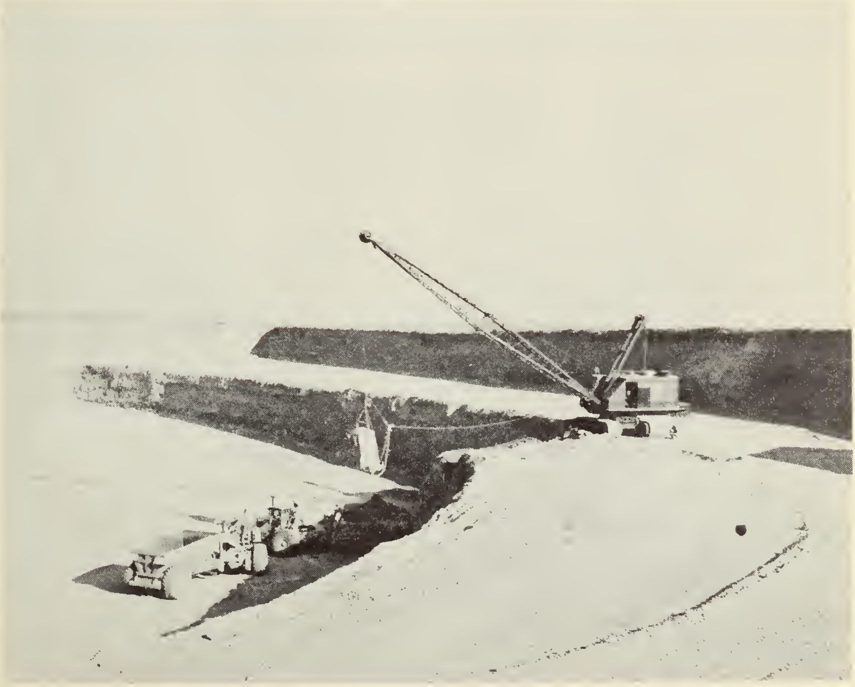

FIGURE 16. Pacific Coast Aggregates, Inc., Kerlinger sand and gravel pit showing benches, dragline, and wagons.

Conveyor belts are arranged so that material from any of the plant storage bins can be carried to any of the truck loading bins. Facilities for loading railroad cars are also at the plant.

Of the products produced, sand represents about 37 percent, gravel 45 percent and crushed rock 18 percent (Williams, E. E., personal communication, 1953).

The normal crew at the plant is 30 men.

Pacific Coast Aggregates, Inc., River Rock Plant. Location: sec. 19, T. 3 S., R. 4 E., M. D. M., 7 miles south of Tracy at the mouth of Corral Hollow Canyon. Ownership: J. P. Etchelet, 522 W. Walnut Street, Stockton, California, and leased by Pacific Coast Aggregates, Inc., when the plant was in operation.

This plant was erected in 1916 by the River Rock Gravel Company (Laizure, 1925, p. 198), and operated by that concern until 1929 when it was merged with Pacific Coast Aggregates, Incorporated. Pacific Coast Aggregates operated the plant continuously until 1947 when it was abandoned in favor of the more modern Kerlinger plant, 2 miles to the northwest (Williams, E. E., personal communication, 1953). E. E. Williams was plant superintendent. Capacity of this plant was 250 tons of finished material per hour.

The deposit was excavated by a 2½-yard electric dragline and hauled 1 mile by rail to the plant. At the plant, the material was belt conveyed to the top of the plant and classified in a series of vibrating screens. Primary crushing was done by a Gates gyratory crusher and secondary crushing by a Symons cone crusher. The plant was also equipped with a screw classifier and a sand wheel. Various sizes of sand, gravel, crushed rock, and road rock were produced and sold in the Tracy-Stockton area. Twenty-five men worked at the plant.

Putnam Sand and Gravel Company. Location: sec. 24, T. 2 S., R. 9 E., 4½ miles southeast of Escalon and ¼ mile north of the Stanislaus River. Ownership: Putnam Sand and Gravel Company, 200 South Santa Rosa Avenue, Modesto, California. G. E. Burton is plant superintendent.

This plant produces sand and gravel which is sold largely in the Oakdale-Modesto area. Maximum plant capacity is approximately 90 tons of finished material per hour. The present plant was erected in 1946 replacing an older plant just to the west which was built in 1924 (Laizure, 1925, p. 196).

A river terrace deposit composed of unconsolidated and poorly stratified sand and gravel on the north side of the Stanislaus River is worked. The deposit averages about 25 feet in depth. The pit ranges from 20 to 30 feet in depth and is about 10 acres in extent. There is little overburden.

The material is excavated by a truck-mounted ¾-yard dragline or clamshell bucket. The excavated material is trucked to a bunker at the plant ¼ mile to the east. From the bunker, the material is sent to the top of the sizing plant by means of a belt conveyor which discharges to a 3-deck vibrating screen. Oversize drops to a Kue Ken crusher from which the crushed material goes by bucket elevator back to the belt conveyor. Screen discharge drops to another 3-deck screen where the material is washed. Oversize from this screen is sent to a cone crusher while the fines are sent to a rake classifier. The various screen and classifier products then drop into storage bins.

Standard sizes of sand, pea gravel, concrete aggregate, and road metal are produced. Some cobbles are also produced. Between 10 and 15 men work at the plant.

Santa Fe (Riverbank) Pit. Location: sec. 23, T. 2 S., R. 9 E., M. D. M., 1 mile north of Riverbank.

This sand and gravel pit was operated by various owners from around 1917 until 1947, when it was abandoned as the deposit had been exhausted. The last operator, M. J. Ruddy, general contractor of Modesto, purchased the pit and plant in 1944. Minus ¾-inch gravel and sand were the principal products.

This operation covered several hundred acres of river terrace gravels of Recent age on the north side of the Stanislaus River. The deposit ranged from 20 to 25 feet in depth and consisted essentially of minus 2-inch material. The deposit was worked with a dragline and the material was delivered to the aggregate plant by dump truck. The material was classified by multiple-deck vibrating screens and dropped into storage bins. All plus 1½-inch material was crushed in a jaw crusher. When in operation, 6 men were employed at the pit and plant.

Tracy Rock and Gravel Company. Location: secs. 9 and 16, T. 3 S., R. 5 E., M. D. M., 3 miles south of Tracy. Ownership: George F. French, P. O. Box 761, Tracy, California, is owner and plant manager. Mr. A. Parker is general superintendent.

The Tracy Rock and Gravel Company operates the largest sand and gravel plant in San Joaquin County. It was erected in 1945. Present

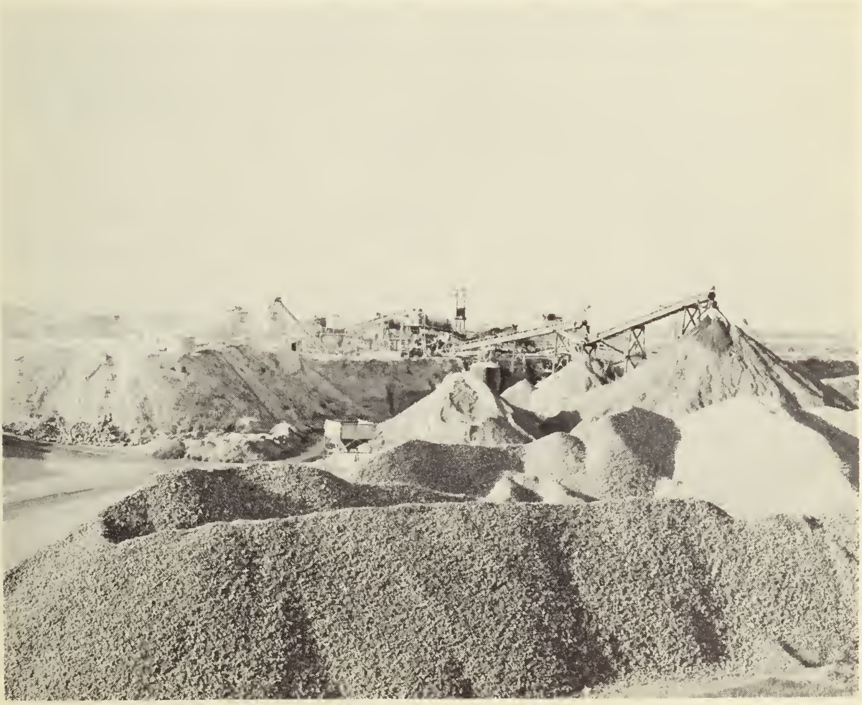

FIGURE 17. Plant and yard stockpile of the Tracy Rock and Gravel Company.

capacity of the plant is 500 tons of finished products per hour. Standard commercial sizes of crushed rock, sand, and gravel are produced and sold in the Stockton, Modesto, and Merced areas, with some shipments going into the San Francisco Bay area (Parker, A., personal communication, 1953). There is also a 150-cubic yard per hour Noble ready-mixed concrete and dry batching unit and a Standard 120-ton per hour hot mix plant.

The pit is located in the alluvial fan of Corral Hollow Creek approximately a mile northeast of the Pacific Coast Aggregates, Inc. pit. Sand and gravel ranges from 35 to 75 feet in depth with a clay-soil overburden ranging from 3 to 16 feet in depth. A few thin lenses of clay are interbedded with the sand and gravel. The pit is mined in 20-foot benches by means of a 1¾-yard Bucyrus Erie dragline which loads the material into 20-ton Euclid bottom-dump wagons. Material is then delivered to underground bunkers and belt conveyed to either the crushing or washing plant. Belt conveyors are used entirely for intraplant transportation of material so that great flexibility is obtained in plant operations. Gravel is cleaned in a 6 by 20-foot rotary scrubber while crushed gravel is scrubbed separately in a 5 by 20-foot unit. There is also a set of twin screw washers in the scrubber unit to wash intermediate sizes of gravel before screening.

Crushing equipment includes a 10 by 36-inch Straub Kue Ken crusher for primary crushing, a 3-foot Telsmith cone, a set of 24 by 42-inch Pioneer rolls, and a set of 30 by 18-inch Universal rolls. Because of increasing demand for finer material, especially by the California Division of Highways, crushing capacity of the plant was recently increased (Lenhart, Jan. 1953, p. 99).

The chief sizes of washed gravel produced at the plant are ¼″ by ¾″, ¾″ by 1½″, and 1½″ by 3″. Road rock produced includes minus 1½ inches, minus 1 inch, and minus 30-mesh. The chief sizes of crushed rock are ¼″ by ½″, ⅜″ by ½″, ¼″ by 10-mesh, ½″ by 10-mesh, and ⅜″ by 10-mesh. Thirty-two men work at the plant.

Claude C. Wood Plant. Location: secs. 12 and 13, T. 4 N., R. 8 E., M. D. M., 3 miles northeast of Clements on the south side of the Mokelumne River. Ownership: Claude C. Wood Company, 686 E. Lockeford, Lodi, California. O. L. O'Reilly is plant superintendent.

This sand and gravel plant was erected in 1942. At the present time, maximum capacity is 100 tons of finished material per hour (O'Reilly, O. L., personal communication, 1953). Standard commercial sizes of sand, gravel, and crushed rock are produced and sold in the Stockton-Lodi area. This plant also supplies a company-owned batching plant at Lodi. There is also a 3000-pound hot mix plant on the property.

The deposit consists of several hundred acres of river terrace gravels and old dredge tailings. There is some contamination consisting of tree trunks, branches, and roots, which are removed at the plant by mechanical means and hand sorting. At the present time a 20-foot river terrace on the river is being worked.

The deposit is worked by a dragline which loads into bottom-dump wagons which in turn deliver the material to the rock plant, half a mile south of the river. At the plant, the material is dumped into underground bunkers from which the material is taken by belt conveyors to a vibrating screen. Oversize from the screen is sent to a Kue

Ken crusher while undersize is sent to the washing plant. Discharge from the Kue Ken crusher is either sent to the crushing plant for further crushing or to the washing plant, depending upon demand for the different types of finished material.

At the washing plant, the material is conveyed to a scrubber with a trommel on the discharge end. Scrubbed material is sent to a log washer where most of the woody material is removed. The washed material is then conveyed to another scrubber and then a 3-deck vibrating screen, the products from which drop into steel storage bins. Undersize from the trommel flows into a spiral classifier from which the sand product is conveyed to a large stockpile while the slime product is discarded.

In the crushing plant, the material is sent to a cone crusher and then conveyed to a 3-deck vibrating screen which discharges into storage bins. If further crushing is desired, products from the screen are conveyed to another cone crusher.

Sand is the principal material produced at the plant. Other sizes produced include ¼ by ½, ⅜ by ¾, ⅜ by 1, 1 by 1½, and 1½ by 2½ inches. Approximately 20 men work at the plant.

Silver

Small amounts of silver have been produced in San Joaquin County as a by-product of gold placer operations. Generally, the amount of silver that has been produced annually in the county is proportional to the amount of placer gold produced.

Silver occurs alloyed with gold in placer deposits in the county and has a similar origin.

MINERAL PROCESSING

Mineral processing industries in San Joaquin County, excluding the clay products industry, which is described separately in this report, includes the manufacture of concrete pipe, lightweight building blocks, and monuments. Until June, 1953, magnesium metal was produced at a plant at Manteca. There are also numerous dry and wet batching plants which produce ready-mix concrete for the construction industry.

Concrete Pipe

There are several concrete-pipe manufacturing plants in Stockton, Lodi and Tracy. Concrete pipe is widely used as irrigation pipe, storm sewers, and water mains and aqueducts. The largest manufacturer in San Joaquin County is the United Concrete Pipe Corporation, which operates a large plant in Stockton and a smaller one in Tracy. Others include the Ed. Spiekerman Concrete Pipe Company, which has plants in Stockton and Lodi, and the J. W. Mumbert Company of Stockton.

All of these plants have similar flowsheets. Raw material consists of the finer sizes of crushed rock, sand, and cement. Most of the crushed rock and sand is produced in the county while cement is important from other counties. The usual proportion used for the manufacture of concrete pipe is 4 to 5 parts sand and crushed rock to one part cement by volume. The raw materials are mixed with water in pug-mills and belt-conveyed to molding machines which shape the pipes. The wet pipes are then carted to yards, sprinkled with water for a period of about two weeks, and air dried.

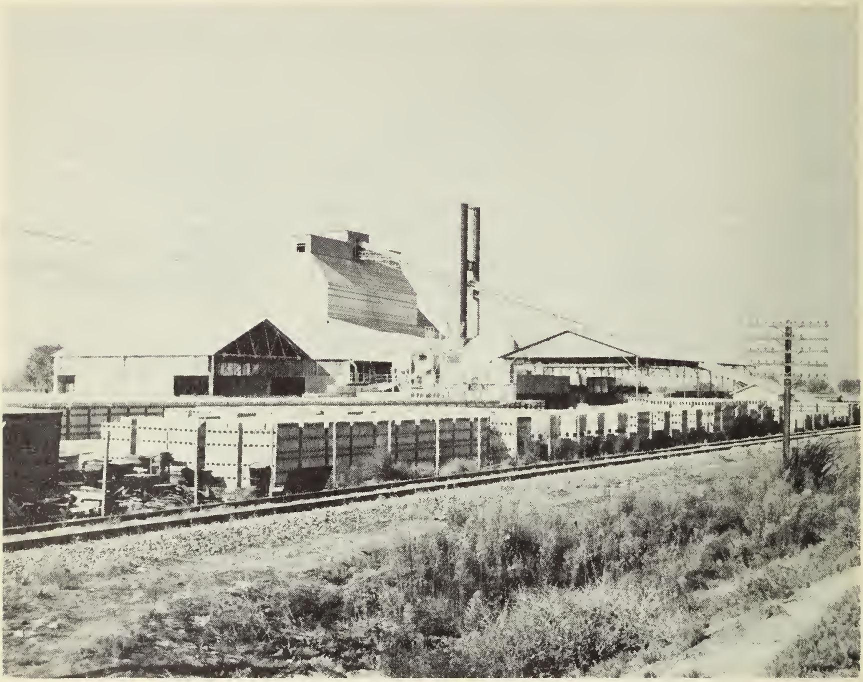

FIGURE 18. Basalt Rock Company plant at French Camp.

Lightweight Building Blocks

Since World War II, large numbers of lightweight concrete blocks have been used in San Joaquin County as well as in much of California in the construction of homes, industrial building, farm structures, and especially housing developments in cities, towns and suburbs. As a result a number of concrete block plants, both large and small, have been erected. The largest plant in San Joaquin County is that of the Basalt Rock Company at French Camp.

Basalt Rock Company Plant. Location: at French Camp, 5 miles south of Stockton on U. S. Highway 50. Ownership: Basalt Rock Company, Inc., P. O. Box 540, Napa, California. Carl Butler is plant superintendent.

This plant was erected in 1946 and production of lightweight concrete blocks known as ''Basalite'' blocks began in the summer of 1947. From 1947 until March, 1953, pumice from company-owned deposits in the Mount George area, Napa County and sand from Escalon, San Joaquin County were utilized in the manufacture of the blocks.

Since March, 1953 expanded shale from a newly erected company-owned plant at Napa Junction, Napa County and sand from company-owned deposits in Napa County have been used. Shale, which is quarried in Napa County, is expanded into pellets in high-temperature inclined rotary kilns at the Napa Junction plant. The pellets of expanded shale have a low specific gravity (less than 1) and are tough and firm in texture. The pellets are screened so that they average $\frac{5}{8}$ inches in size. The screened pellets and sand are shipped to the French Camp plant by truck and deposited in overhead storage bunkers.

The material in the storage bunkers is automatically weighed and deposited by gravity in electrically driven pugmixers where it is mixed with water and cement. The ratio of expanded shale to sand used is approximately three to one by weight. The mixed material then flows by gravity into hoppers. From the hoppers, the material is fed to electrically operated Besser automatic block-forming machines where it is shaped in dies. The cast blocks are pressed out of the dies and placed on racks. There are three block machines at the plant, each capable of turning out three blocks at once or nine blocks per minute. The dies on the block machines can be changed to produce 153 different shapes and sizes. The principal size produced at the present time is an 8 x 8 x 16-inch building block.*

The cast blocks are placed in steam tunnels and steamed for 3 hours at a temperature of 180° F. They are then left in the tunnel for 8 to 12 hours and then trucked to the drying yard where they are air-dried for a period of at least 30 days.

Basalite blocks are used in the construction of homes, farm and industrial buildings and outdoor fireplaces. This plant largely serves the Sacramento-Stockton area where large numbers of tract houses are being constructed at the present time. About 1600 tons of aggregate per month are consumed at the plant. Twenty-one men are employed at the plant.

U. S. Government Magnesium Plant

Location: 2 miles west of Manteca., Ownership: The plant is owned by the U. S. Government, General Services Administration, and was operated by the Kaiser Magnesium Company. H. D. Phillips was plant superintendent and William Zinzer was plant engineer.

This plant is one of six magnesium plants using the silicothermic process that were constructed during World War II. The Permanente Metals Corporation received the government contract for the construction of this plant in March, 1942. The first magnesium metal was produced about 5 months later. The plant was shut down in 1944 after having produced 22,368,900 pounds of magnesium ingots (Schrier, 1952, p. 148). Because of the rearmament program and the resulting demand for magnesium metal, the plant was reactivated in February, 1951 by the Kaiser Magnesium Company and ingot production began on June 6, 1951. The plant was again shut down by government order on June 1, 1953.

Magnesium was produced by the silicothermic or ferrosilicon process. This process is more costly than the electrolytic process of producing magnesium, but its advantages are that plants using the silicothermic process can be built quickly and calcined dolomite and ferrosilicon, the chief raw materials, are seldom in short supply.

Hard-burned dolomite from the Kaiser dolomite plant at Natividad, California, 75 percent ferrosilicon from the Kaiser plant at Permanente, California, and acid grade fluorspar from Zuni, New Mexico were shipped in by truck. The fluorspar acted as a catalyst and increased yield. At the grinding plant, the dolomite was ground to 80 percent minus 100 mesh and the ferrosilicon to 70 percent minus 200 mesh in Raymond grinders. The material was then mixed in an automatic batching plant so that the charge consisted of 4.5 parts dolomite, 1 part ferrosilicon, and 2.5 percent by weight of fluorspar.

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* Butler, Carl, personal communication, 1953.

FIGURE 19. Entrance to the Holly Sugar Corp. beet sugar refinery at Tracy, showing yard stockpiles of limestone, coke, and burned limestone.

The mixed material was sent to pellet machines where it was compressed into walnut-sized pellets. The pellets were conveyed to a bagging machine where they were bagged in paper bags, 40 to 50 pounds of pellets per bag. The bagged pellets were then carted to the retorts.

There are 1024 retorts at the Manteca plant housed in two large furnace buildings. Each building contains 32 furnaces and each furnace contains 16 horizontal retorts. The retorts are made of cast nickel-chrome-steel alloy and are 10½ feet long and 10 inches in diameter. A steel sleeve jacket, through which water circulates, is at the outer or condensing end of the retort. Each retort is charged with five bags of pellets and left open for about 15 minutes so that the paper bags burn away and most of the moisture present is driven off. A metal heat dam and a 1½-foot steel sleeve, on which the magnesium condenses, were inserted and the retort was sealed.

The retorts were heated with natural gas fuel to a temperature of 2140° F. and electrically-driven vacuum pumps in the basement, which are connected to the furnaces, reduced the pressure in the retorts.

Magnesium condensed in coarse crystals as a muff on the sleeve. About 35 pounds of magnesium crystals were recovered from each retort charge (Zinzer, William, personal communication, 1953). The retorts were unsealed and the muffs removed and carted to the foundry. At the foundry the muffs were refined by being melted in steel pots to which Dow 230 flux is added. The pure magnesium was then ladled from the pots and cast into 17-pound ingots in molds mounted on a conveyor and stacked in the storage yard. The magnesium produced was Grade B and met Specification P-71 which calls for 99.8 percent magnesium, less than 0.02 percent copper, 0.005 percent iron and 0.001 percent nickel (Schrier, 1953, p. 149).

Residue resulting from the retorting operation, which was composed chiefly of dicalcium silicate and iron, was piled in the yard. Sludge from the melting pots was run through a dross recovery unit where flux and magnesium metal were recovered.

A total of 580 employees worked three shifts at the plant.

MINERAL UTILIZATION

Besides the various manufacturers and processors who use mineral and rock products as their principal raw materials, many other industries in San Joaquin County use varying amounts of mineral and rock products in their manufacturing processes. These include beet sugar refining, wine making, canning, the fertilizer industry, foundries, and manufacturers of cattle and poultry feeds. Mineral products used in these industries include limestone, bentonite, diatomite, sulfur, asbestos, silica sand, mineral paint, coal, and calcium chloride.

Bentonite

Bentonite, a type of clay with high absorptive powers, is used for various purposes in San Joaquin County. In foundries, bentonite is used as a bonding agent in molding sands; in wineries and in the manufacture of putty, it is used as a filter aid; in oil production, bentonite is used as a suspending agent in gas-well drilling fluids. Much of the bentonite used in the county is imported from Wyoming.

Diatomite

Substantial quantities of processed diatomite are used in San Joaquin County. Probably the greatest amount is consumed by the many wineries in the Lodi area, where it is used as a filter aid in the clarification of wine. The two beet sugar refineries used processed diatomite as an aid in the filtering of the thick juices in the sugar refining process.

Much of the diatomite used in the county is imported from the Johns-Manville Corporation plant at Lompoc, California.

Gypsum

Appreciable quantities of gypsum are used in the fertilizer industry. It is used as a soil conditioner to counteract excess acidity. Minor amounts of gypsum are used in the wineries. Most of the gypsum used in San Joaquin County is from California deposits.

Limestone

Large quantities of limestone are consumed each year in the two beet sugar refineries in San Joaquin County.

The Spreckels refinery at Manteca, a non-Steffen factory, uses about 12,000 tons of limestone per year (Ballou, 1951, p. 10). The limestone used in a non-Steffen factory must contain 95 percent calcium carbonate, 4 percent or less magnesium carbonate, and not more than 1 percent silica. The limestone is burned with coke in vertical Belgian-type kilns to produce quicklime and carbon dioxide gas. The quicklime is slaked with sugar-bearing water and then added to the raw beet juice while the carbon dioxide gas is allowed to bubble through the mixture. Calcium carbonate is precipitated out, taking with it most of the impurities and non-sugars in the beet juice.

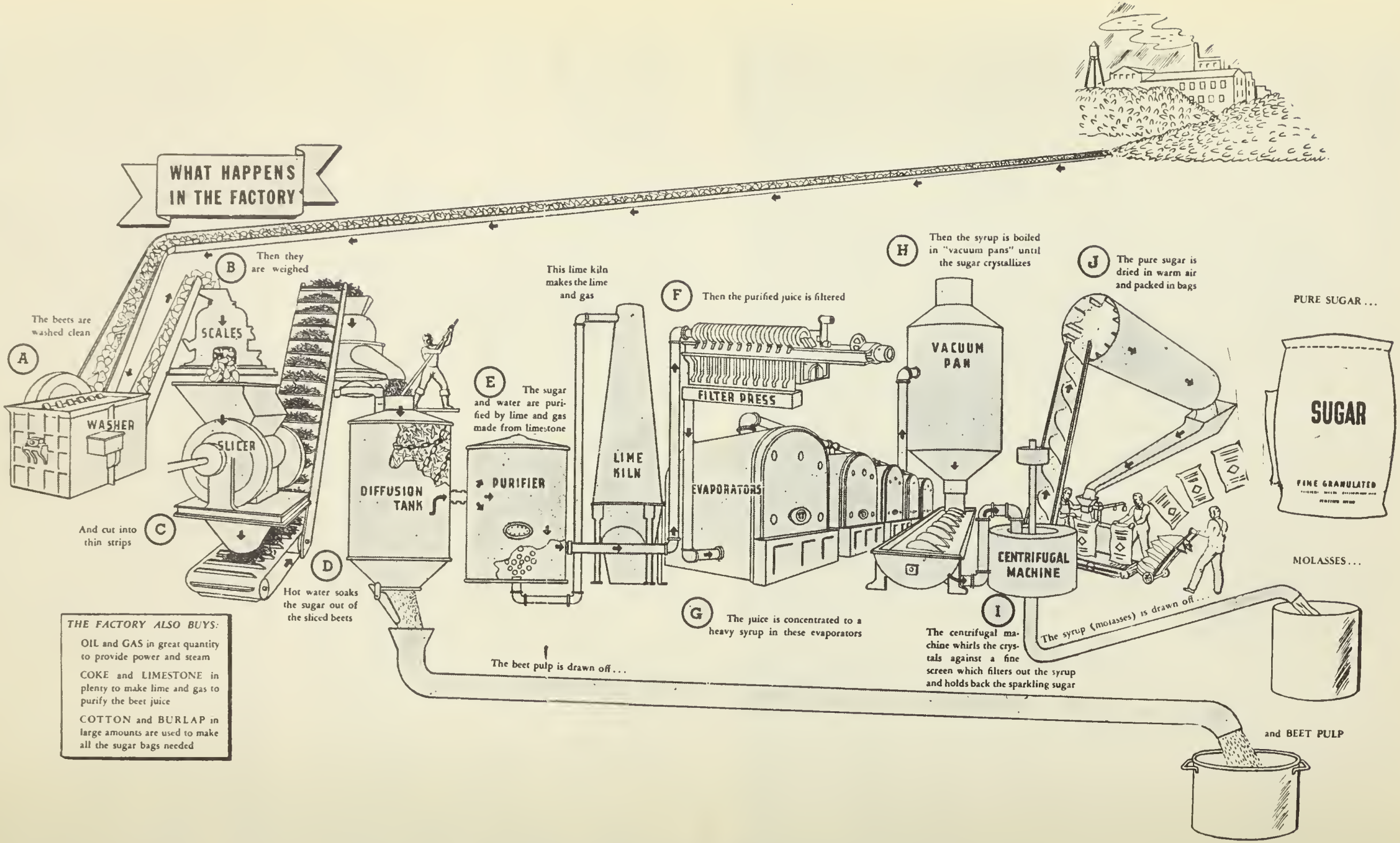
WHAT HAPPENS IN THE FACTORY
A
The beets are washed clean
WASHER
B
Then they are weighed
SCALES
C
And cut into thin strips
SLICER
D
Hot water soaks the sugar out of the sliced beets
DIFFUSION TANK
E
The sugar and water are purified by lime and gas made from limestone
PURIFIER
This lime kiln makes the lime and gas
LIME KILN
F
Then the purified juice is filtered
FILTER PRESS
G
The juice is concentrated to a heavy syrup in these evaporators
EVAPORATORS
H
Then the syrup is boiled in "vacuum pans" until the sugar crystallizes
VACUUM PAN
I
The centrifugal machine whirls the crystals against a fine screen which filters out the syrup and holds back the sparkling sugar
CENTRIFUGAL MACHINE
J
The pure sugar is dried in warm air and packed in bags
PURE SUGAR . . .
SUGAR
FINE GRANULATED
MOLASSES . . .
The syrup (molasses) is drawn off . . .
The beet pulp is drawn off . . .
and BEET PULP
THE FACTORY ALSO BUYS:
OIL and GAS in great quantity to provide power and steam
COKE and LIMESTONE in plenty to make lime and gas to purify the beet juice
COTTON and BURLAP in large amounts are used to make all the sugar bags needed

FIGURE 20. Flow sheet of the Spreckels beet sugar refinery at Manteca.
Courtesy of Spreckels Sugar Company.

The Holly refinery at Tracy, a Steffen factory, utilizes 17,500 tons of limestone per year (Ballou, 1951, p. 10). In the Steffen process, the limestone is hard burned in vertical kilns and the lime is then pulverized. The pulverized lime is added to a molasses solution and a precipitate is formed. This precipitate is redissolved in a sugar solution and carbon dioxide is allowed to bubble through. Calcium carbonate is precipitated out removing with it most of the impurities.

Limestone used at both plants is shipped in by railroad from the Cool-Cave Valley limestone deposit in El Dorado County. The by-product chalklike precipitated calcium carbonate or ''pond lime'' from both refineries is used as a soil conditioner in the beet fields.

Smaller amounts of limestone are used for various purposes in other industries in the county such as in the manufacture of fertilizer and cattle and poultry feeds. Finished marble, which is imported largely from Vermont, is used in the manufacture of monuments.

Silica Sand

Silica sand is used in a wide variety of ways in San Joaquin County industries. A large amount is used as molding sand in the manufacture of iron and steel castings; some is used in the manufacture of putty; some is used as engine sand by the railroads. Small amounts are consumed in pottery making, and still smaller amounts are used as an abrasive in monument manufacture. Although much of the sand consumed in the county is produced in other counties of the state, some special types of molding sand are imported from Illinois.

Soda Ash

Soda ash is used to precipitate lime in beet sugar refining, as a refining agent in iron foundries, and in the manufacture of cleaning compounds. Most of the soda ash used in the county is produced from saline lakes in southern California.

Sulfur

Substantial quantities of sulfur are used in various industries in the county. It is used in the manufacture of fertilizer, as a bleaching agent in beet sugar refining, and as a deoxidizing agent in foundry work. Much of it is imported from the Gulf Coast area.

Talc

Talc from Inyo and San Bernardino Counties is used in San Joaquin County, chiefly as a raw material in the manufacture of ceramic ware. Minor amounts are used in foundries and by the monument manufacturers.

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TABULATED LIST OF SAN JOAQUIN COUNTY MINERAL DEPOSITS

San Joaquin County mineral deposits are listed in alphabetical order by commodity in the following table. The number in the first column refers to the map, plate 1, in pocket.

References given in the last column refer to the bibliography accompanying this report. The first number after each name is the abbreviated date as given in the bibliography; the second number, that following the colon, is the page reference.

CLAY AND CLAY PROCESSING

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	Carnegie Brick and Pottery Company		33,34	3S	4E	MD	Operated a brick and terra cotta plant in Corral Hollow from 1904 until 1912. The plant was equipped with 45 kilns. Clay was obtained from the Tesla coal and clay mine in Alameda County. (Aubury 06:227-228; Lowell 14:607-608; Anderson and Pack 15:211; Boalich and others 20:94; Laizure 25:190; Dietrich 28:208; Huey 48:62).
	Carnegie shale pit		34	3S	4E	MD	Hard clay shales were quarried in Corral Hollow and used in the manufacture of paving brick at the Carnegie Brick and Pottery Company plant in 1906. (Aubury 06:228.)
	Joaquin Pottery	Joaquin Pottery Company McKinley Avenue, Stockton					Produced clay products at a plant in Stockton from 1939 until 1942.
	Laurel Potteries	Laurel Pottery Company, McKinley Ave., Stockton					(Herein.)
	Pacific Clay Products Company plant	Pacific Clay Products Company, Box 145, Station A, Los Angeles					(Herein.)
	Roberts Island Brick Company						Erected a brick plant in 1906 at Roberts Island. This plant was later consolidated with the San Joaquin Brick plant. (Aubury 06:254; Lowell 14:608.)
	San Joaquin Brick Company						Operated a brick yard in Stockton in the 1890's, which was formerly owned by the San Joaquin Improvement Company. The plant had a coal-fired Hoffman kiln. Clay was obtained from a pit at the plant. (Watts 93:394.)
67	San Joaquin Brick plant	Stockton Building Materials Co., 711 South Mason St., Stockton					(Watts 93:394; Aubury 06:255; Lowell 14:608; Boalich and others 20:94; Laizure 25:188; Dietrich 28:208; herein.)

CLAY AND CLAY PROCESSING (CONT'D)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	San Joaquin Improvement Company Brickyard	San Joaquin Improvement Company, Stockton					Manufactured brick at a plant in Stockton in the 1880's. Clay was obtained from a pit 40 feet deep near the San Joaquin River (Irelan 88:561; Watts 93:394; Crawford 96:618.)
	Silica Products Company						May have utilized clay in Stockton in 1920. (Boalich and others 20:95.)
	Stockton Brick Company						Operated a brick plant around 1906 at Roberts Island. The stiff mud process was used, and the plant was equipped with a 16-compartment Hoffman kiln. (Aubury 06:255.)
68	Stockton Brick and Tile Company	Stockton Brick and Tile Company, P.O. Box 547, Stockton					(Laizure 25:188-189; Dietrich 28:208-209; herein.)
	Stockton Building Materials Company						See San Joaquin Brick Plant.
	Stockton Fire and Enamel Brick Company						See Stockton Fire Brick Company.
	Stockton Fire Brick Company (Stockton Fire and Enamel Brick Company)						Produced fire and insulating bricks at a plant in Stockton from 1912-32. Special oil-fired kilns were employed. (Lowell 14:608-610; Boalich et al., 20:95: Laizure 25:189 Dietrich 28:208, 209-212.)
	Stockton Pottery Company	Stockton Pottery Company, 600 E. Main St., Stockton					Produced clay products in a plant at Stockton. The plant was closed in 1932.
	Stockton Terra Cotta Co.						Manufactured drain and sewer pipe and terra cotta ware in a 3-kiln plant in Stockton in the 1890's. (Watts 93:394; Crawford 96:618.)

DIATOMACEOUS EARTH

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	Staples Ranch						Diatomaceous earth was found on Staples Ranch many years ago. (Aubury 06:363; Eakle 22:92; Laizure 25:190.)

GLASS SAND

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	Corral Hollow prospect		32	3S	4E	MD	(Huey 48:61; herein.)
	Pacific Window Glass Co.						Manufactured window glass at a plant in Stockton during 1902-06. Glass sand was imported from Monterey County. (Aubury 06:279.)
	Stockton Window Glass Co. (Western Stockton Glass Plant)						Manufactured window glass and glass products at a plant in Stockton intermittently from 1901-21. Glass sand was imported from Monterey County. (Lowell 14:625; Laizure 25:191.)
	Western Stockton Glass Plant						See Stockton Window Glass Company.

GOLD

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	American gold dredges	American Gold Dredging Company, Camanche					Operated three dredges in the Camanche district from 1914-22. Operated in San Joaquin County in 1918-20. An average of 10.25¢ of gold per yard was recovered from a total of 22 million cubic yards handled. (Logan 18:31; Laizure 25:191.)
	California gold dredge	California Gold Dredging Company, 351 California St., San Francisco					Operated floating connected-bucket dredge with 81 buckets of 6 cubic ft. capacity in 1940-41 in the Jenny Lind district. (Averill 46:282.)
	Camanche dredges						See Gold Hill dredges.
69 70	Gold Hill dredges	Gold Hill Dredging Co., 311 California St., San Francisco					(Averill 46:282; herein.)
	Gold Valley dredge	Gold Valley Dredging Company					Operated dry land washing plant and a 1/2-cu. yd. dragline in the Camanche district in February-May, 1942. (Averill 46:282.)
	Gruwell dredge	C.E. Gruwell, Angels Camp					Operated a $1\frac{1}{2}$-cu. yd. dragline dredge on the McGurk ranch, Bellota district in 1940. (Averill 46:283.)
	Lobicassa dredge	Lobicassa Company, Box 812, Sacramento					Operated a $1\frac{1}{2}$-cu.yd. dragline dredge on the Foster Ranch, Camanche district in January-May, 1942. (Averill 46:282.)
	McGurk property	San Gruco Company, Angels Camp					Operated a $1\frac{1}{2}$-cu.yd. dragline dredge on the McGurk ranch, Bellota district in 1940. (Averill 46:283.)
	Mikes gulch	Kunkle and Ferris, Le Grand					Operated a dragline dredge in the Clements district in 1935.

GOLD (CONT'D)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	Smith-Notterman Dredge	Smith-Notterman Company 245 West Rose St., San Francisco					Operated a 1-3/4-cu.yd. dragline dredge on the Cady and Lewallen ranches, Bellota district in 1941-42. (Averill 46:283.)
	Wallace dredge	Wallace Dredging Company, 311 California St., San Francisco					Operated a 3-cu. ft. dredge near Wallace on Bear Creek from 1936-39.
	Watkins dredge	A.G. Watkins and Sons, Linden					Operated a 2-cu. yd. dragline dredge in the Linden district from 1938-42. (Averill 46:283.)
	K.D. Winship Estate	K.D. Winship Estate 350 Post St., San Francisco					Operated a dragline dredge in the Camanche district in 1938.

GYPSUM

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	Vernalis						Selenite of doubtful economic value occurs at Vernalis. (Eakle 22:271; Laizure 25:191.)

LIMESTONE

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
71	California Lime and Cement Company quarry		33	3S	4E	MD	(Aubury 06:79; Laizure 25:191; Huey 48:62; herein.)

MANGANESE

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Callahan prospect	P.J. Connolly, P.O. Box 811, Tracy	12	4S	4E	MD	In 1918, 255-foot adit driven in sandstone and shale. No ore was visible. (Trask and others 43:166; 50:221.)
	Corral Hollow						See Ladd.
72	Crocker prospect	J.R. Gallaher, P.O. Box 112, Banta	35	4S	4E	MD	Undeveloped prospect, 5 miles south of the Ladd mine. (Bradley and others 18:64; Laizure 25:192; Trask and others 43:166; 50:221.)
73	Cummings (Lone Tree)	J.A. Rustan, Rt. 2, Box 292, Tracy	13	4S	4E	MD	(Bradley and others 18:67-69; Laizure 25:193; Trask and others 43:86, 166; 50:221-222; herein.)
	Doak						See Mahoney.
74	Fabian	P.J. Connolly, P.O. Box 811, Tracy	2	4S	4E	MD	Part of the Ladd mine. Bradley and others 18:65; Trask and others 43:86, 166; 50:222; Huey 48:63,66; herein.)
	Johnson						See Mahoney.
75	Ladd (Corral Hollow)	P.J. Connolly, P.O. Box 811, Tracy	2,11	4S	4E	MD	(Watts 90:564; Crawford 96:507; Aubury 06:368; Harder 10:160-161,167; Lowell 14:621-622; Anderson and Pack 15:208; Bradley and others 18:64-67; Huguenin and Costello 21:166; Laizure 25:192; Trask and others 43:85-86,166; 50:223-266; Jenkins 50:326-327; Huttl 52:26-30; herein.)
	Lone Tree						See Cummings.
76	Mahoney (Doak)	M.R. Chaves, Rt. 2, Box 408, Tracy	11	4S	4E	MD	(Watts 90:564; Lowell 14:622; Bradley and others 18:67; Laizure 25:193; Trask and others 43:167; 50:226-227; herein.)
77	Scott prospect	M.P. Escover, Jr. Star Route, Box 10 Livermore	34	4S	4E	MD	Five low-grade ore beds occurring in thin chert beds interbedded with sandstone. (Trask and others 43:167; 50:227-228; Huey 48:66.)

MANGANESE (CONT'D)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	Section 13						See Cummings.

MINERAL PAINT

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	Ladd	P.J. Connelly, P.O. Box 811, Tracy	2	4S	4E	MD	Earthy red hematite as shale occurs in the Ladd manganese mine. (Laizure 25:191; Symons 30:156.)

NATURAL GAS FIELDS

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
78	Galt		1	4N	6E	MD	(Clark and others 51; herein.)
79	Lodi		9,10, 15,16	4N	7E	MD	(Walling 47:70; Clark and others 51; herein.)
80	McDonald Island		25	2N	4E	MD	(Knox 43:588-590; herein.)
			19,24, 30,31	2N	5E	MD	
81	Roberts Island		23	1N	5E	MD	(Herein.)
82	Thornton		28,29	5N	5E	MD	(Walling 47:71; Clark and others 51; herein.)
83	Tracy		15,16 22,23	2S	5E	MD	(Beckwith 43:586-587; herein.)
84	Vernalis		23,25	3S	6E	MD	(Herein.)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	Arington and Putnam Sand and Gravel Company						See Putnam Sand and Gravel Company.
	Bellota pit		5	3N	9E	MD	Sand, gravel, and crushed rock were produced intermittently at a pit at Bellota during the 1920's. Excavated material was sent through a crushing, washing, and screening plant. Capacity was 250-350 tons per day. (Laizure 25: 196-197.)
	G.W. Bianchiani						Produced sand and gravel from a pit at Lodi in 1939-40.
85	Clements gravel pit	A.B. Warner, Martell	14	4N	8E	MD	(Herein.)
	Corral Hollow pit		35	3S	4E	MD	Paving gravel was produced from a deposit in Corral Hollow Canyon in 1906. (Aubury 06:322.)
	J.S. Cowan						Produced sand and gravel from a pit near Escalon in 1935.
	D.M. Dyer						See Mokelumne pit.
	Flockhart and Langley	Louis F. Flockhart Clements	11	4N	8E	MD	Operated a sand and gravel pit in the Mokelumne River channel from 1939-41. (Piper and others 39:35.)
	G.F. Gilbert						Produced sand and gravel from a pit at Stockton in 1937.
	L. Lorentzen						Produced sand and gravel from a pit at Lodi in 1935 and 1939.
	Marks pit	Frank Marks, Newman	17	3S	5E	MD	Small amounts of pit-run sand and gravel were produced intermittently from 1931-45. When operating, about 200 tons per day were produced.
	Miller (Myers) pit		S½17	2S	8E	MD	Sand and gravel were quarried from a bench deposit near the Stanislaus River in 1920's. Excavated material was

SAND AND GRAVEL (CONT'D)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Miller (Myers) pit (contd)						sent through a sizing and washing plant. Capacity was 200 tons per day. (Laizure 25:197.)
	M.J.B. project	M.J.B. Construction Company, Elks Building, Stockton	14	2S	7E	MD	Sand produced from a leveling project is being used as fill in the U.S. Highway 99 project between Ripon and Manteca.
86	Mokelumne pit	Neil Ellsbury, Clements	14	4N	8E	MD	(Averill 46:282; herein.)
	Mokelumne Sand and Gravel Company						See Mokelumne pit.
	Myers pit						See Miller pit.
87	Pacific Coast Aggregates, Inc., Kerlinger plant	Pacific Coast Aggregates, Inc., 400 Alabama St., San Francisco	16	3S	5E	MD	(Lenhart 47:70-73; 53:96; herein.)
88	Pacific Coast Aggregates, Inc., River Rock plant	Pacific Coast Aggregates, Inc., 400 Alabama St., San Francisco	19	3S	5E	MD	(Laizure 25:198-199; herein.)
89	Pereira pit	Alfred Pereira, 1410 Holly Drive, Tracy	17	3S	5E	MD	(Herein.)
90	Putnam Sand and Gravel plant	Putnam Sand and Gravel Company, 200 South Santa Rosa Ave., Modesto	24	2S	9E	MD	(Laizure 25:196; herein.)
	Riverbank Sand Company		23	2S	9E	MD	See Santa Fe Sand and Gravel Company. (Laizure 25:197-198)
	River Rock Gravel Company						See Pacific Coast Aggregates, Inc., River Rock plant.

SAND AND GRAVEL (CONT'D)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
91	Santa Fe (Riverbank) pit		23	2S	9E	MD	(Laizure 25:197-198; herein.)
	P.F. Sivers						See Mokelumne pit.
	Tidewater Southern Railroad Company pit						See Miller gravel pit.
92	Tracy Rock and Gravel Company pit	George F. French, P.O. Box 761, Tracy	9,16	3S	5E	MD	(Lenhart 53:99-100; herein.)
93	Warner Pit	Elmer J. Warner, 1103 Sycamore St., Stockton	5	2N	9E	MD	Produced sand and gravel intermittently from 1936-40. A 20-foot terrace and river bed deposit was worked with a slack line cableway and a power shovel. The material was screened, and plus 1½-inch material was sent to a jaw crusher. Production was 100-150 tons per day.
	Western Pacific Carbona pit		9	3S	5E	MD	Pit-run sand and gravel were produced from a pit on Corral Hollow Creek for use as railroad ballast in 1925. (Laizure 25:200.)
	Western Pacific Carnegie pit		34	3S	4E	MD	Sand and gravel were excavated from a pit in Corral Hollow Canyon and used as railroad ballast about 1910. In the early 1930's, gravel was used in concrete for the Hetch Hetchy project. The deposit is composed of rounded pebbles of andesite and sandstone. (Anderson and Pack 15:212; Huey 48:62.)
94	Claude C. Wood plant	Claude C. Wood, 686 E. Lockeford, Lodi	12,13	4N	8E	MD	(Herein.)

PHYSICAL
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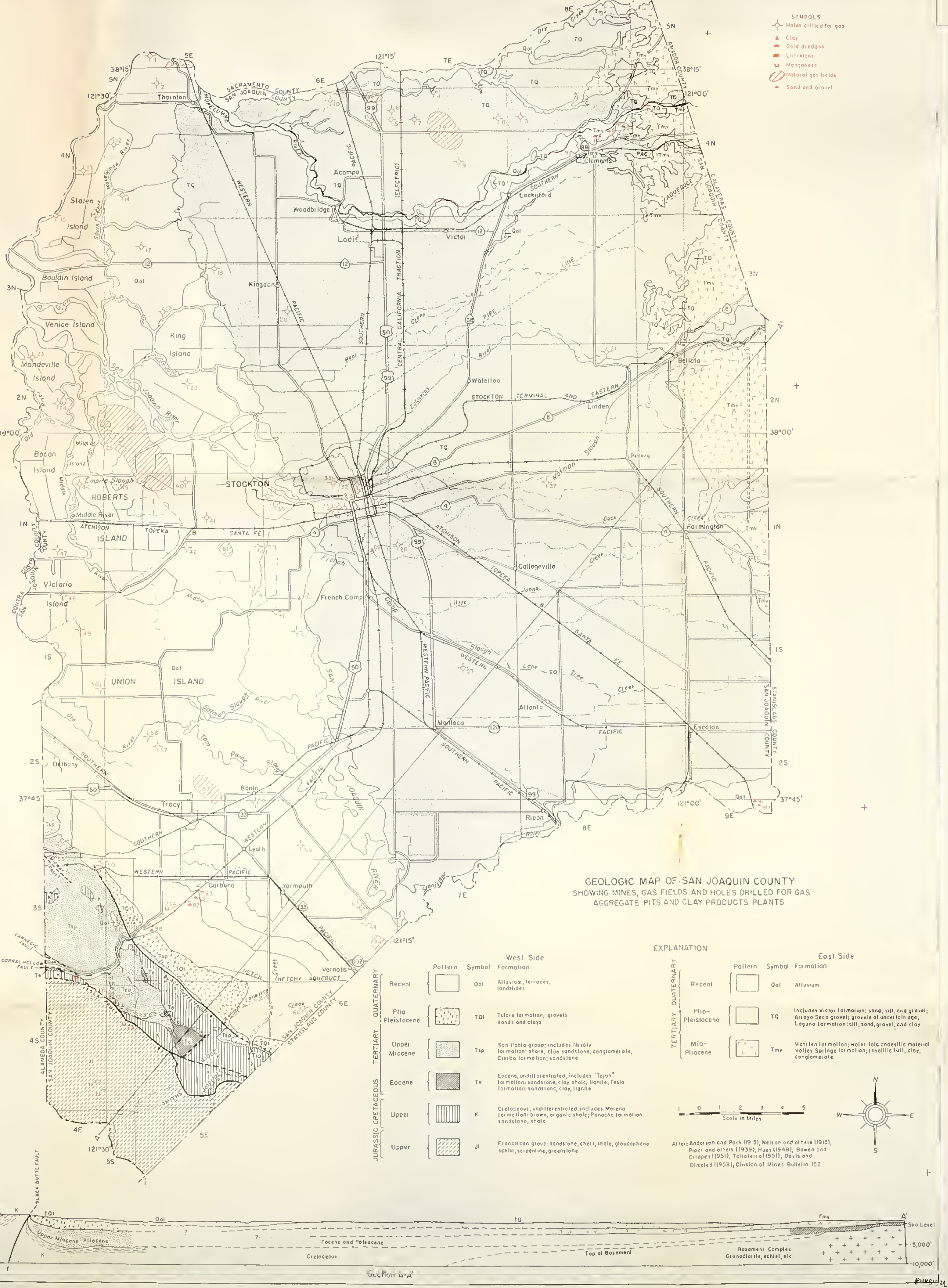
MINERAL DEPOSITS AND HOLES DRILLED FOR GAS

Map No.	T.	R.	Sec.	Name
				HOLES DRILLED FOR GAS COMPANY AND WELL
1	5N	5E	29	Allison and Prestridge Dincill 1
2	5N	5E	32	Amerada Pet. Corp., Blossom Comm. 1
3	4N	8E	7	Alliance Oil Co., No. 1
4	4N	7E	4	Bankline Oil Co., Community 3-1
5	4N	7E	7	Amerada Pet. Corp., Community 7-1
6	4N	7E	7	Union Oil Co., Union Brazos-Grussendorf 1
7	4N	7E	8	Amerada Pet. Corp., Comm. 8-1
8	4N	7E	12	Pacific Pet. Producers, No. 1
9	4N	7E	22	Bankline Oil Co., Community 22 A-1
10	4N	6E	3	Amerada Pet., Thompson-Folger 1
11	4N	6E	12	Bankline Oil Co., Community 2-1
12	4N	4E	13	Shell Oil Co., Staten Island 2
13	4N	4E	22	Brazos Oil & Gas Co., Brown 1
14	4N	4E	25	Amerada Corp., Powell Core Hole 1
15	4N	4E	33	Brazos Oil & Gas, George H. Jensen A-1
16	4N	4E	35	Shell Oil Co., Staten Island 1
17	3N	5E	7	Amerada Corp., Atkins-Kroll-Core Hole 1
18	3N	5E	15	Amerada Corp., Coldani Core Hole 1
19	3N	8E	29	Amerada Pet. Corp. G & P Core Hole 1
20	3N	6E	29	Honolulu Oil Corp., Brack Comm. R-1
21	2N	8E	2	Amerada Pet. Corp., Mariencl 25-2
22	2N	6E	9	Shell Oil Co., Pacific States 1
23	2N	4E	5	Standard Oil Co. of Calif., Mandeville Island 1
24	2N	4E	16	Shell Oil, Mandeville Island 1
25	2N	4E	28	Rawn, William L., Mildred Island 1
26	1N	8E	6	Richfield Corp., East Stockton 2
27	1N	8E	5	Richfield Corp., East Stockton 1
28	1N	7E	18	Standard Oil Co. of Calif., Faltoaks Community 1
29	1N	6E	2	Pacific Gas & Elec. Co., No. 4
30	1N	6E	2	Pacific Gas & Elec. Co., No. 5
31	1N	6E	2	Pacific Gas & Elec. Co., No. 10
32	1N	6E	3	Pacific Gas & Elec. Co., Citizens 1
33	1N	6E	3	Pacific Gas & Elec. Co., Citizens 2
34	1N	6E	7	Utilities Pet. Corp., Rough and Ready Island 1
35	1N	6E	7	Utilities Pet. Corp., Rough and Ready 1
36	1N	6E	10	Pacific Gas & Elec. Co., No. 3
37	1N	6E	10	Pacific Gas & Elec. Co., No. 7
38	1N	6E	10	Pacific Gas & Elec. Co., Stockton 1
39	1N	6E	12	Pacific Gas & Elec. Co., No. 6
40	1N	5E	4	Standard Oil Co., West Coast Life 2-1
41	1N	5E	15	Standard Oil Co., Holt Community 1
42	1N	5E	21	Madison, Lemos & Malloe, Budd 1
43	1N	5E	24	Standard Oil Co., Woods Community 1
44	1N	5E	35	Standard Oil Co., Roberts Island Community 1
45	1N	4E	1	M. R. & M. Syndicate, Pacific States 2
46	1N	4E	3	Ohio Oil Co., Pacific States 1
47	1N	4E	21	Universal Consolidated Oil Co., Pacific States 1
48	1N	4E	33	Amerada Pet. Corp., Borden 1
49	1S	4E	10	Amerada Pet. Corp., Calif. Packing Corp. 1
50	1S	4E	28	Ohio Oil Co., Wm. C. Ferguson 1
51	1S	6E	6	Ohio Oil Co., Edward W. Avila 1
52	1S	6E	8	Texas Co., The, Laurence-Stephan 1
53	1S	7E	22	Westates Pet. Corp., Spence 1
54	2S	4E	33	Tracy Oil Co.
55	2S	4E	33	Wallenberg, Daley 1
56	2S	5E	8	Seaboard Oil Co., Hall 1
57	2S	5E	6	Seaboard Oil Co., Mary Simos 1
58	2S	5E	24	Standard Oil Co. of Calif., Gerhart Community 1
59	2S	6E	32	Shell Oil Co., Inc., Wright 1
60	3S	4E	2	Coast Exploration Co., T.-F.-1 1
61	3S	4E	24	Milham Exploration Co., May 1
62	3S	4E	24	Milham Exploration Co., May 2
63	3S	6E	14	Union Oil Co., Tracy Land 1
64	3S	6E	23	Standard Oil of Calif., Blewett Comm. 3
65	4S	5E	5	Milham Exploration Co., Connolly 1
66	4S	8E	8	Union Oil Co., Schnabel 36-5
				CLAY
67	1N	6E	..	Stockton Brick Plant
68	1N	6E	..	Stockton Brick and Tile Company
				GOLD
69	4N	8E	16	Lower Camanche Dredge, Gold Hill Dredging Company
70	4N	8E	8	Upper Camanche Dredge, Gold Hill Dredging Company
				LIMESTONE
71	3S	4E	33	California Lime and Cement Company
				MANGANESE
72	4S	4E	35	Crocker
73	4S	4E	13	Cummings (Lone Tree)
74	4S	4E	2	Fabian
75	4S	4E	2, 11	Ladd (Corral Hollow)
75A	3S	5E	17	Teekay Mill
76	4S	4E	11	Mahoney (Doak)
77	4S	4E	34	Scott
				NATURAL GAS FIELDS
78	4N	6E	1	Galt
79	4N	7E	{9, 10 15, 16}	Lodi
80	{2N 2N	4E 5E	25 {19, 24 30, 31}	McDonald Island
81	1N	5E	23	Roberts Island
82	5N	5E	28, 29	Thornton
83	2S	5E	{15, 16 22, 23}	Tracy
84	3S	6E	23, 25	Vernalis
				SAND AND GRAVEL
85	4N	8E	14	Clements
86	4N	8E	14	Mokelumne
87	3S	5E	16	Kerlinger Plant, Pacific Coast Aggregates, Inc.
88	3S	5E	19	River Rock Plant, Pacific Coast Aggregates, Inc.
89	3S	5E	8	Pereira
90	2S	8E	24	Putnum
91	2S	9E	23	Santa Fe
92	3S	5E	9, 10	Tracy
93	2N	8E	5	Warner
94	4N	8E	12, 13	Claude C. Wood


SYMBOLS
Holes drilled for gas
Clay
Gold dredges
Limestone
Manganese
Natural gas fields
Sand and gravel
STOCKTON
Lodi
Thornton
Woodbridge
Acampo
Lockeford
Clements
Victor
Kingdon
Waterloo
Linden
Bellota
Peters
Farmington
Collegeville
French Camp
Manteca
Escalon
Ripon
Lathrop
Banta
Tracy
Bethany
Carbona
Vernalis
Staten Island
Bouldin Island
Venice Island
King Island
Mandeville Island
Bacon Island
Roberts Island
Victoria Island
Union Island
SACRAMENTO COUNTY
SAN JOAQUIN COUNTY
AMADOR COUNTY
CALAVERAS COUNTY
STANISLAUS COUNTY
ALAMEDA COUNTY
CONTRA COSTA COUNTY
Mokelumne River
San Joaquin River
Calaveras River
Stanislaus River
Dry Creek
38°15'
38°00'
37°45'
121°30'
121°15'
121°00'
TESLA FAULT
BLACK BUTTE FAULT
CORRAL HOLLOW FAULT
CARNEGIE FAULT
A
A'
Sea Level
5,000'
10,000'
Jl
K
Te
Tol
Qal
TQ
Tmv
Upper Miocene–Pliocene
Eocene and Paleocene
Cretaceous
Top of Basement
Basement Complex
Granodiorite, schist, etc.

Section A-A'

GEOLOGIC MAP OF SAN JOAQUIN COUNTY
SHOWING MINES, GAS FIELDS AND HOLES DRILLED FOR GAS
AGGREGATE PITS AND CLAY PRODUCTS PLANTS

EXPLANATION

West Side

		Pattern	Symbol	Formation
QUATERNARY	Recent	☐	Qal	Alluvium, terraces, landslides
QUATERNARY / TERTIARY	Plio-Pleistocene	▨	Tol	Tulare formation; gravels sands and clays
TERTIARY	Upper Miocene	▨	Tsp	San Pablo group; includes Neroly formation: shale, blue sandstone, conglomerate, Cierbo formation: sandstone
TERTIARY	Eocene	▨	Te	Eocene, undifferentiated, includes "Tejon" formation: sandstone, clay shale, lignite; Tesla formation: sandstone, clay, lignite
CRETACEOUS	Upper	▥	K	Cretaceous, undifferentiated, includes Moreno formation: brown, organic shale; Panoche formation: sandstone, shale
JURASSIC	Upper	▨	Jf	Franciscan group: sandstone, chert, shale, glaucophane schist, serpentine, greenstone

East Side

		Pattern	Symbol	Formation
QUATERNARY	Recent	☐	Qal	Alluvium
QUATERNARY / TERTIARY	Plio-Pleistocene	☐	TQ	Includes Victor formation: sand, silt, and gravel; Arroyo Seco gravel; gravels of uncertain age; Laguna formation: silt, sand, gravel, and clay
TERTIARY	Mio-Pliocene	▨	Tmv	Mehrten formation: water-laid andesitic material Valley Springs formation: rhyolitic tuff, clay, conglomerate

Scale in Miles

After: Anderson and Pack (1915), Nelson and others (1915), Piper and others (1939), Huey (1948), Bowen and Crippen (1951), Taliaferro (1951), Davis and Olmsted (1953), Division of Mines Bulletin 152

Physical Sciences

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STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES

CALIFORNIA JOURNAL OF MINES AND GEOLOGY

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APRIL 1955

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DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO 11
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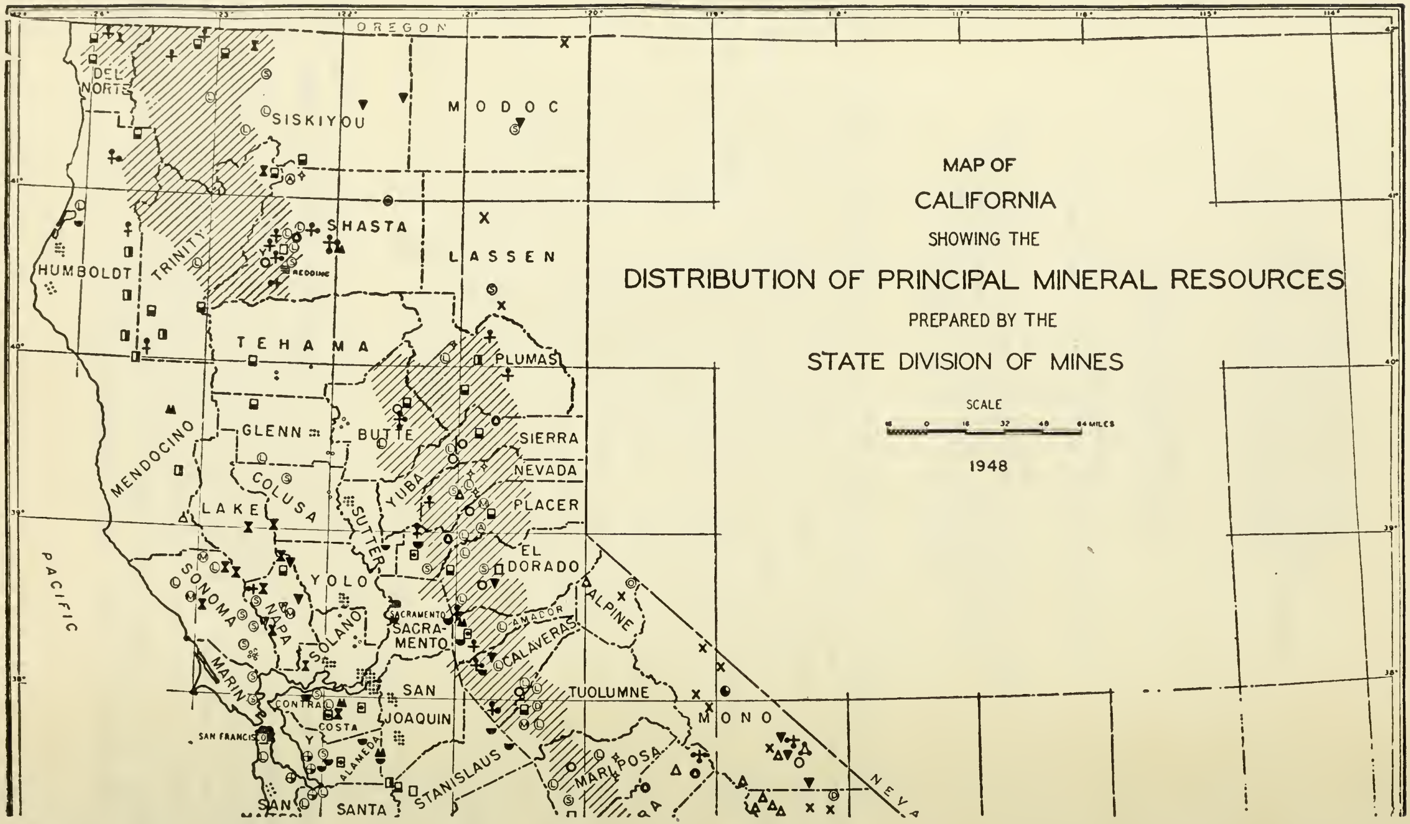
MAP OF
CALIFORNIA
SHOWING THE
DISTRIBUTION OF PRINCIPAL MINERAL RESOURCES
PREPARED BY THE
STATE DIVISION OF MINES
SCALE
0
16
32
48
64 MILES
1948
OREGON
NEVA
PACIFIC
DEL NORTE
SISKIYOU
MODOC
HUMBOLDT
TRINITY
SHASTA
REDDING
LASSEN
TEHAMA
PLUMAS
GLENN
BUTTE
SIERRA
NEVADA
MENDOCINO
COLUSA
YUBA
PLACER
LAKE
SUTTER
EL DORADO
YOLO
SONOMA
NAPA
SOLANO
SACRAMENTO
SACRA-MENTO
AMADOR
ALPINE
CALAVERAS
MARIN
SAN FRANCISCO
CONTRA COSTA
SAN JOAQUIN
TUOLUMNE
MONO
ALAMEDA
STANISLAUS
MARIPOSA
SAN
SANTA

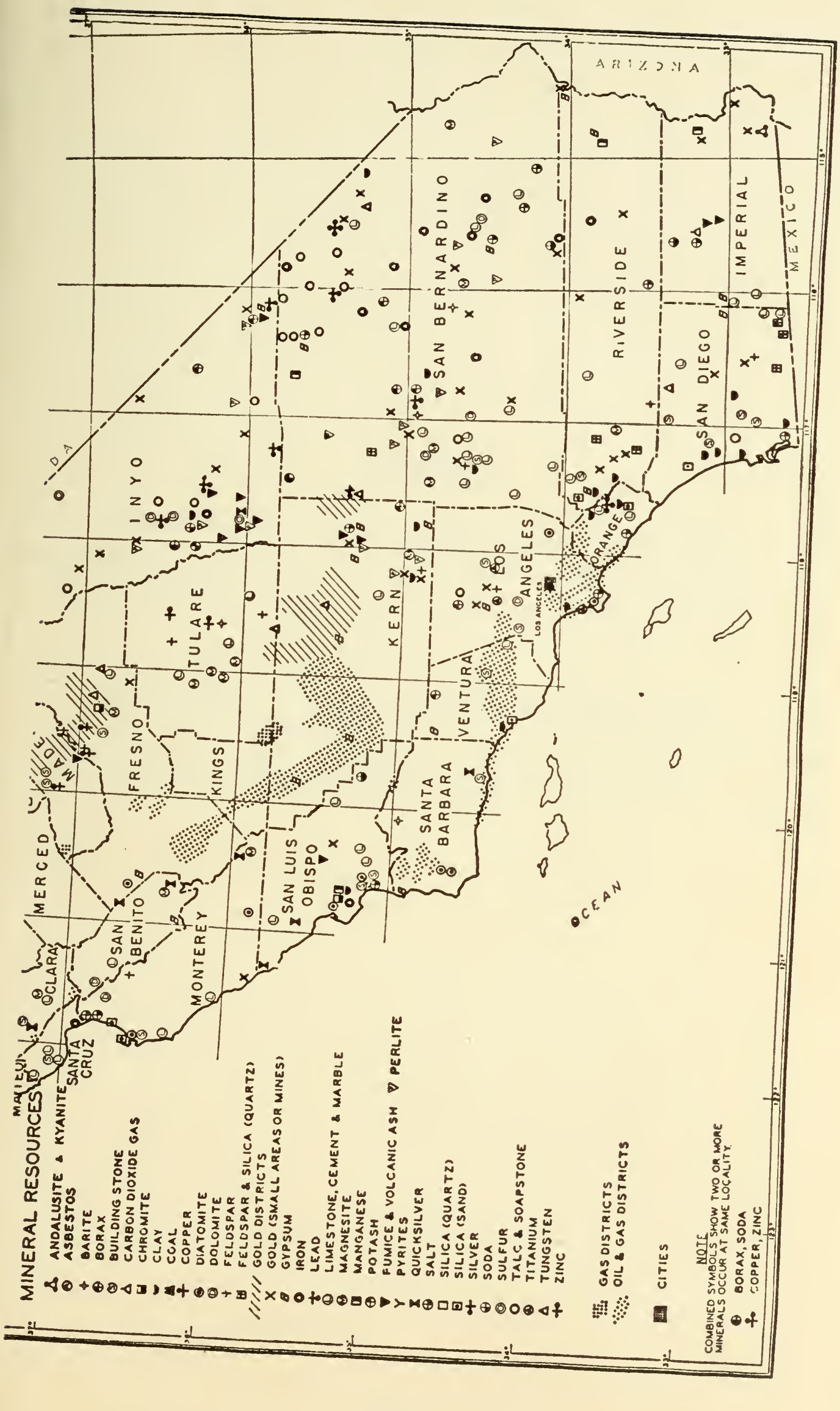
MINERAL RESOURCES
ANDALUSITE & KYANITE
ASBESTOS
BARITE
BORAX
BUILDING STONE
CARBON DIOXIDE GAS
CHROMITE
CLAY
COAL
COPPER
DIATOMITE
DOLOMITE
FELDSPAR
FELDSPAR & SILICA (QUARTZ)
GOLD DISTRICTS
GOLD (SMALL AREAS OR MINES)
GYPSUM
IRON
LEAD
LIMESTONE, CEMENT & MARBLE
MAGNESITE
MANGANESE
POTASH
PUMICE & VOLCANIC ASH
PERLITE
PYRITES
QUICKSILVER
SALT
SILICA (QUARTZ)
SILICA (SAND)
SILVER
SODA
SULFUR
TALC & SOAPSTONE
TITANIUM
TUNGSTEN
ZINC
GAS DISTRICTS
OIL & GAS DISTRICTS
CITIES
NOTE
COMBINED SYMBOLS SHOW TWO OR MORE MINERALS OCCUR AT SAME LOCALITY.
BORAX, SODA
COPPER, ZINC
MATEO
SANTA CRUZ
CLARA
SAN BENITO
MONTEREY
MERCED
MADERA
FRESNO
KINGS
TULARE
INYO
SAN LUIS OBISPO
SANTA BARBARA
KERN
VENTURA
LOS ANGELES
Los Angeles
ORANGE
SAN BERNARDINO
RIVERSIDE
SAN DIEGO
IMPERIAL
ARIZONA
MEXICO
NEVADA
OCEAN

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Plate 2. Geologic map of Sacramento County showing location of mines, sand and gravel pits, gold dredges, natural gas fields, holes drilled for natural gas, and clay pits ..... In pocket

3. Cenozoic correlation section, Rio Vista—River Island—Thornton gas fields, Sacramento County, California ..... In pocket

THE PROCESSING OF PERLITE

By H. A. Stein * and J. B. Murdock *

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ABSTRACT

The success of a perlite processing plant to make efficient use of raw material and fuel and to make a product conforming to close specifications for size distribution and density depends upon the interplay of four variables which are: (1) the nature of the perlite rock used, (2) the maximum temperature reached by the perlite particles, (3) the extent to which water has been driven out of the particles before their softening point is reached, and (4) the size distribution of the particles fed into the furnace.

The three types of perlite furnaces now in general use are the horizontal stationary furnace, the co-current rotary furnace, and the vertical furnace. Each of these furnaces must work into a collection and cooling system in order to be a complete perlite processing plant. Pre-heaters for the treatment of the raw perlite prior to furnacing can be furnished with each of the three types of furnaces listed above.

THE FOUR VARIABLES

When particles of perlite are heated to a soft consistency, the combined water present in the glass vaporizes, forming steam that expands each particle into a mass of glass foam. The basic process seems quite simple, but in commercial installations the problem is made more complicated by the necessity of making efficient use of both raw material and fuel, and of producing an expanded aggregate conforming to close specifications of size distribution and density. The ability of an operation to fulfill these requirements depends upon the interplay of four variables:

(1) The nature of the perlite rock used.
(2) The maximum temperature reached by the perlite particles.
(3) The extent to which water has been driven out of the particles before their softening point is reached.
(4) The size distribution of the particles fed into the furnace.

Types of Perlite Rock. Perlites may be classified according to their softening temperature, that temperature where the glass is just soft enough to be deformed by escaping steam. This ranges from 1400° F for some perlites to as high as 2000° F for others. Low-temperature perlites are sometimes referred to as ''lively'' perlites and they generally have high ''effective water content;'' that is, they have more of the type of combined water which contributes to expansion. High-temperature perlites are often called ''dead'' perlites, and they have less ''effective water content.'' Some perlite rocks, usually the more lively ones, have numerous fracture planes that result in a tendency for the particles to fly apart explosively when heated.

---

* The Perlite Corporation, Front and Yarnall Streets, Chester, Pennsylvania.

Perlites which are livelier than those being exploited commercially on a large scale include the red pitchstone on the Animas Highway south of Lordsburg, New Mexico, and the light gray perlitic rock with obsidian balls from the Gusman-Lobb claim on Picket Post Mountain, Superior, Arizona. Medium perlites include the pumiceous gray perlite from Socorro, New Mexico (Great Lakes Carbon Corporation), the black glass from Lovelock, Nevada (United States Gypsum Co.), the Hollinger perlite, a dark gray perlite from Pioche, Nevada (Combined Metals Reduction Co.), the gray perlite from New Mexico, just south of Antonito, Colorado (F. E. Schundler & Co.), and the gray perlite from Klondike, California (California Perlite Corporation). Dead perlites include the John-Clare perlite, a solid green glass from southwest of Florence, Colorado (Great Lakes Carbon Corporation), and the light gray perlite from northeast of Grants, New Mexico (United States Gypsum Company). It should not be inferred that one of these perlites is better than another.

Maximum Temperature Reached. When a particle of perlite is heated just to the softening point, very little expansion will take place because the steam lost in the initial expansion raises the softening point of the glass and causes it to resolidify. As the temperature rises, it will expand until the loss of water due to expansion has caused the particle to resolidify. Therefore the degree of expansion of a particle of perlite will be proportional to the excess temperature reached above the original softening temperature. Because most commercial furnaces are fuel-fired and involve dropping the perlite directly into a fast-moving flame, it is often difficult to attain, in the interior of a particle, the temperature required for the amount of expansion desired, especially when the feed is coarse. Four solutions to this problem are: (1) Pre-heat the feed to some temperature just below the point where effective water begins to be driven off. This reduces the amount of heating which must be done in the flame. (2) Adjust the ratio of fuel to primary air in the flame. In the range of flames used in expanding perlite, low-air flames are cooler but slower moving, whereas high-air flames are hotter but faster moving. The best flame is a compromise which gives the optimum retention time and temperature combination for most thorough heating of the particles. (3) Reduce the draft in the furnace to as low a point as possible without causing ''puffing'', a discharge of fine expanded perlite from the burner end of the furnace. (4) Provide some means for holding the raw material in the flame until it is expanded. In the updraft vertical furnace, gravity holds the feed in the flame until it is light enough to be blown out. In the co-current rotary furnace, lifting flights constantly recirculate the perlite through the flame until it is expanded.

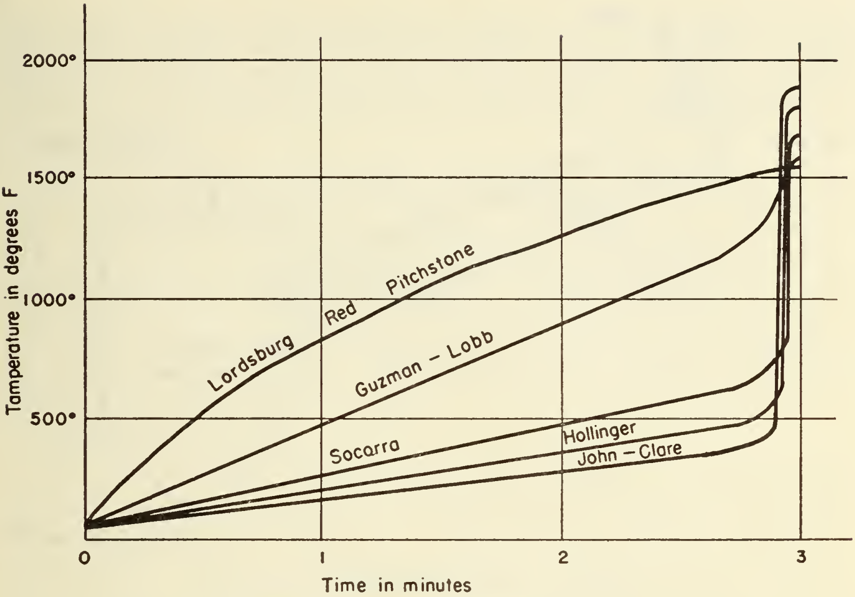

FIGURE 1. Typical time-temperature curves for 10:1 expansion of 16-mesh particles of five perlites.

Amount of Water Driven Off Before Expansion. While it would seem possible to limit the amount of expansion of perlite by limiting the temperature of the furnace and therefore the temperature attained by the particles of feed, the most uniformly expanded material is obtained when the furnace is as hot as possible without causing fusion of perlite to the walls. For this reason it is desirable to have some other means of limiting the expansion of the perlite. One way is to drive off a controlled amount of the effective water content from the particle before the softening temperature is reached. This pre-heating can be done in the same furnace as is used for expansion, using the waste heat from the flame, or it can be done in a separate pre-heater.

Size Distribution of the Feed. When the feed contains only particles of essentially the same size, whether coarse or fine, it is relatively easy to give each particle the proper pre-heat time-temperature curve. It will then be delivered to the flame at the right temperature and with the correct amount of combined water remaining, and it can be held in a flame of the proper temperature for the right length of time. However, in most operations the top 10 percent of the feed is approximately 16 times as coarse as the bottom 10 percent. This makes it difficult to give proper treatment to all particles.

If the pre-heat retention time is only a minute or two, the fines will attain a higher temperature than the coarse particles, because the fines have more surface area per given weight and less thickness for the heat to penetrate, both properties that facilitate heat transfer. If the purpose of pre-heating is to deliver the feed to the flame at as high a temperature as possible without driving off effective water, then it is desirable to pre-heat both coarse and fine particles to the same tempera-

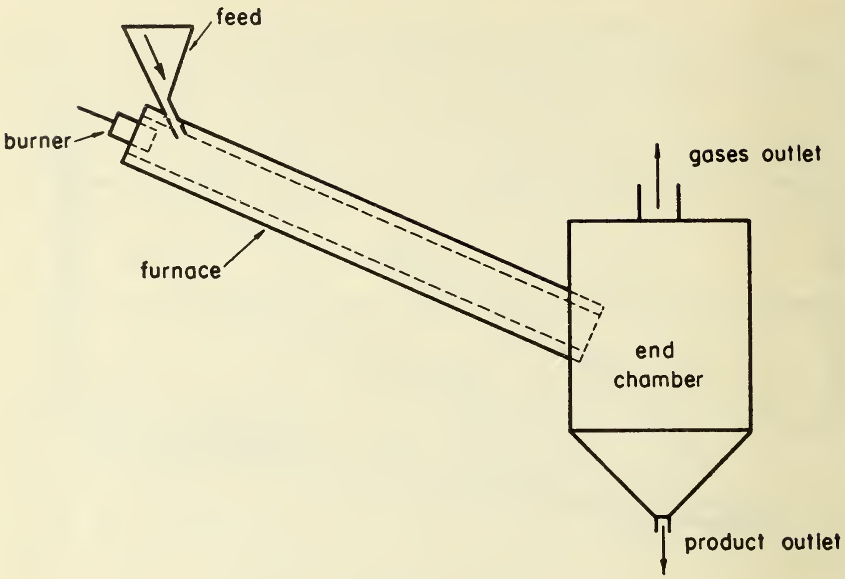

FIGURE 2. Horizontal stationary furnace.

ture. This can be done by using a long pre-heat retention time and a low pre-heat temperature. On the other hand, it is often desirable to drive more effective water from the fines than from the coarse particles in order to prevent the fines from being over-expanded in the flame. This can be done by using a short pre-heat time and a higher pre-heat temperature.

The relative ability of coarse and fine particles to become heated in the flame to the temperature needed for expansion is very important in the production of a uniformly expanded aggregate. As in preheating, the fines tend to become heated more rapidly than the coarse particles. One way to prevent this is to drive more of the effective water from the fines in pre-heating so as to keep them from being overexpanded at the high temperatures needed for the coarse pieces. Another way is to employ particle separation, a characteristic possessed at least to a small degree by all furnaces in which the feed is dropped into a flame, because the finer particles tend to be blown out of the flame more rapidly than the coarse particles, thereby giving them the shorter retention time they require.

PERLITE FURNACE TYPES

Since the publication of our last paper on perlite furnace design,* no further work has been done on three types of furnaces described there and no examples of these types are known to be in commercial operation. These types are: the counter-current rotary furnace, the indirectly fired rotary furnace, and the multiple-hearth furnace. These furnaces operated best when producing very large particles from lively perlites, whereas at present the principal interest is in the production of intermediate and fine aggregates (minus 8 mesh) from the medium and dead perlites which are commercially available. The horizontal stationary furnace, the co-current rotary furnace, and the vertical furnace are the furnace types now being used commercially and are discussed below.

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* Murdock, John B., and Stein, A., 1950, Comparative furnace designs for expansion of perlite: Am. Inst. Min. Met. Eng., vol. 187, p. 111.

Horizontal Stationary Furnace. The horizontal stationary furnace consists of a tube 10 to 20 feet long and 6 inches to 2 feet in diameter. The tube is generally refractory-lined, and although early models were horizontal, there has been a tendency toward making them more and more inclined, the latest examples being inclined as much as 30° from horizontal. The burner and the feeder are located at the upper end of the tube, and the lower end discharges into a large settling chamber, (known as an end-chamber) where most of the product settles out, except for a small portion which is carried out the top with the hot gases.

Since the heating time afforded by the horizontal stationary furnace is never over 2 seconds and is often only a fraction of a second, particles of perlite coarser than 16 mesh cannot be properly expanded. Even minus 16 mesh feed must be subjected to a furnace temperature much higher than the softening temperature of the glass in order to transfer the necessary amount of heat to expand the larger particles. At this high temperature, the finer components of the feed are likely to expand too much, producing an excess of ''fly fines'' which are hard

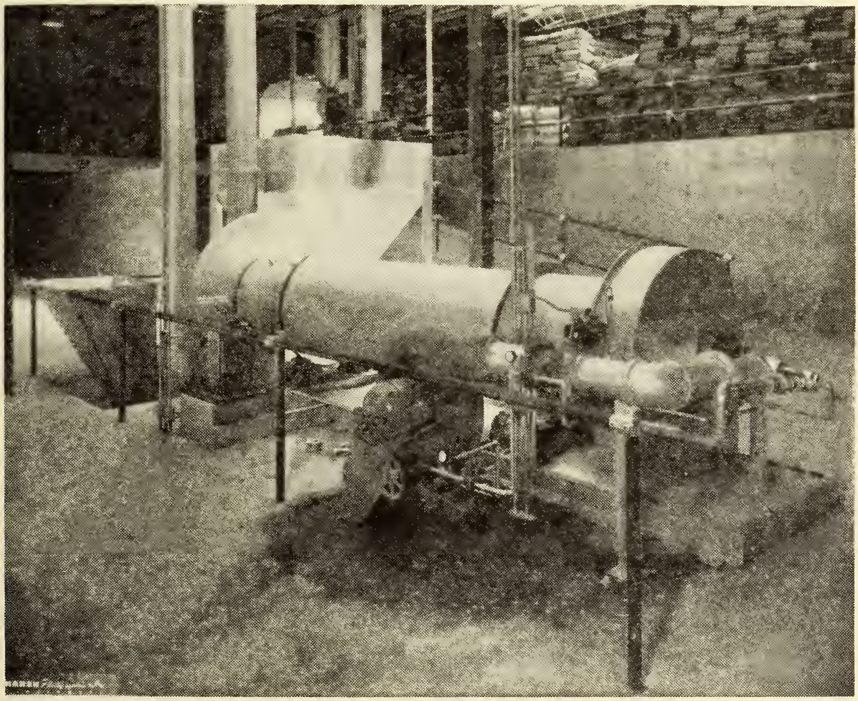

FIGURE 3. A horizontal rotary perlite processing furnace operated by Indoken Perlite Company, Cincinnati, Ohio. *Marsh Photographs photo.*

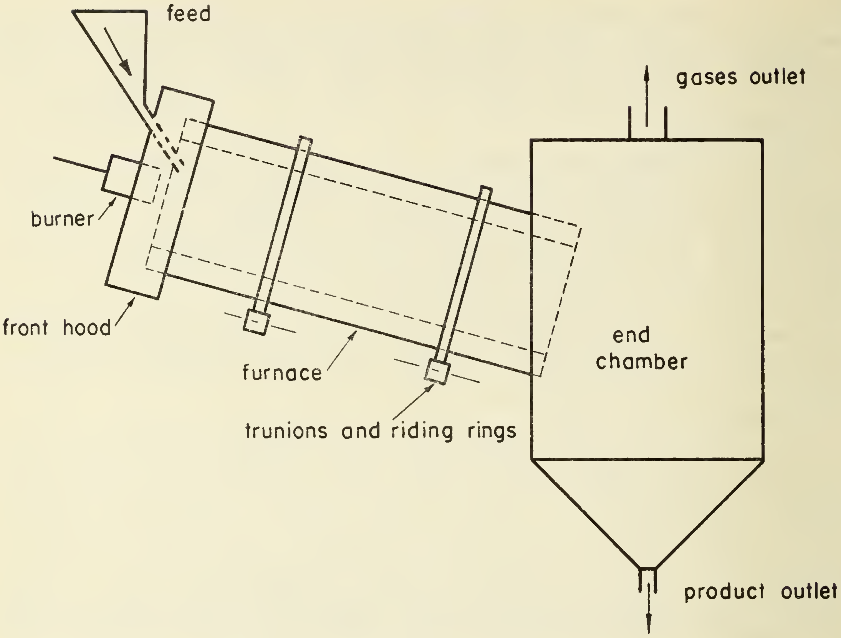

FIGURE 4. Co-current rotary furnace.

to collect and have no large scale uses if caught. The soft, cool, low primary air flames which are necessary for the expansion of even moderately lively perlites do not provide enough velocity to move the product out of the furnace. For these reasons, it is advisable in this type of furnace to use a dead glass which expands properly at high temperature and has a short retention time, sized finely and closely, with neither plus 16- nor minus 50-mesh particles present in the feed.

Co-current Rotary Furnace. The co-current rotary furnace is essentially a horizontal furnace which is rotated instead of being stationary. The ones in operation at the present time range in length from 10 feet to 30 feet and in diameter from 1 foot to 4 feet. Most are lined with firebrick but some have an alloy lining. They usually have lifting flights near the burner end and are mounted at a slight angle to the horizontal.

The obvious advantage of the rotating tube over the stationary one is that the rotation can help carry the product from the furnace. The flame can then be adjusted to the single purpose of properly heating the perlite and is relieved of the task of conveying the perlite out of the furnace. This enables the co-current rotary furnace to process a coarser feed than the stationary furnace. The very coarse particles can be lifted and dropped repeatedly through the flame until the heat has had a chance to penetrate them to the interior thereby giving complete and even expansion. When the feed is dropped into the flame the fine particles are immediately expanded and blown out of the furnace and the coarse particles drop on through to be later recirculated through the flame by the lifting flights. When this is done, the perlite gets some preheating before it is finally dropped into the flame by the lifting flights.

Vertical Furnace. The vertical furnace consists of a vertical cylinder 1 or 2 feet in diameter and 10 to 20 feet high. Some of them are lined with firebrick but more of them are made of high-temperature alloy. The burner is located at the bottom and the hot gases pass out the top of the furnace. The raw perlite is fed into the side of the furnace at a point above the burner and all the expanded perlite is carried out the top of the furnace into a large tank next to the furnace which acts as an end-chamber in separating most of the expanded perlite from the hot gases.

The characteristic product from a vertical furnace is one where the coarse particles are of lower density than the intermediate and fine particles. This is because all particles expand until their density is low enough for the hot gases to carry them vertically out of the furnace, and the density necessary for a large particle to be lifted by a given air velocity is lower than the density necessary for a smaller particle to be lifted by this same air velocity.

Vertical furnaces are best suited for the expansion of dead perlites with a close size distribution of feed.

Pre-heaters. Any of the three furnace types described above may be operated with a pre-heater inserted between the feeder and the expanding furnace. Pre-heating allows a broader size distribution to be used in the feed, permits the use of livelier perlites, and reduces the amount

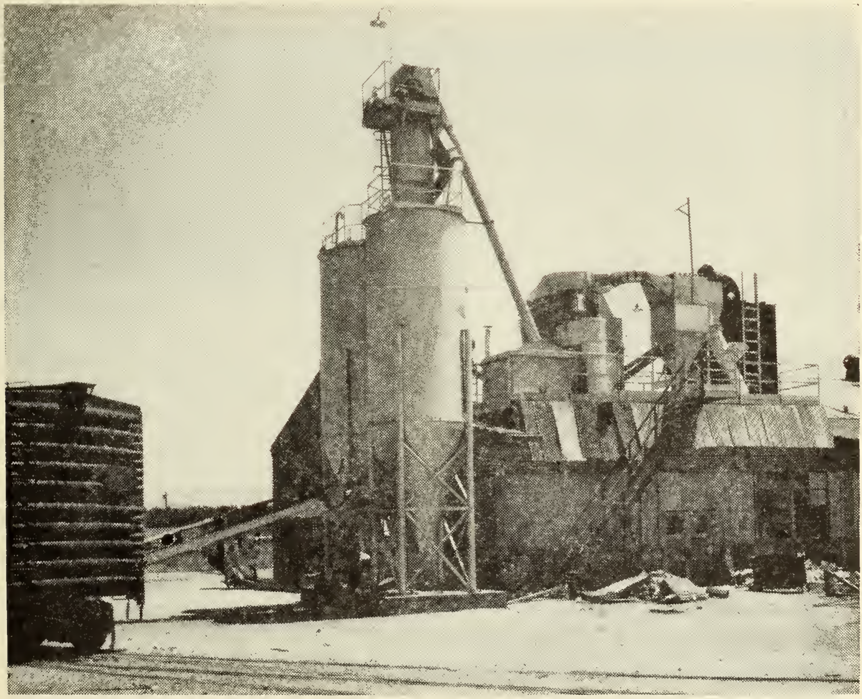

FIGURE 5. American Perlite Corporation plant, Richmond, California. Perlite is processed in a vertical furnace and the expanded perlite is collected by cyclones and stored in steel storage tanks. Cyclone collecting system partly exposed on roof of building and steel storage bins for unexpanded perlite are on outside of building.

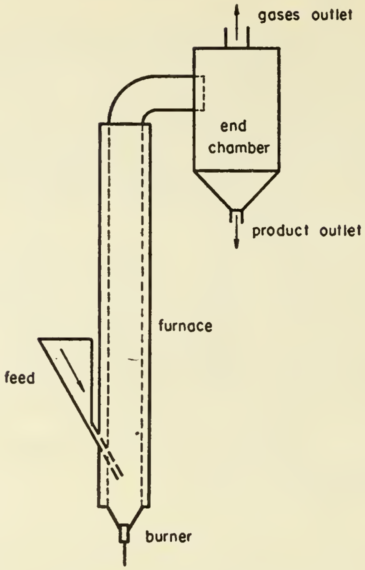
gases outlet
end chamber
product outlet
furnace
feed
burner

FIGURE 6. Vertical furnace.

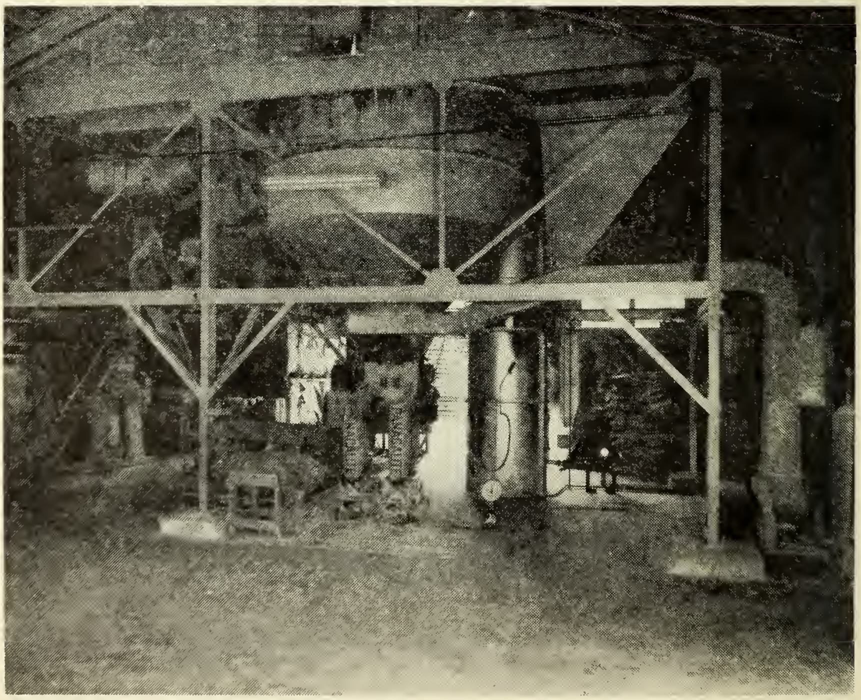

FIGURE 7. Interior view of vertical perlite processing plant operated by Panacalite Pacific, Inc., Los Angeles, California.

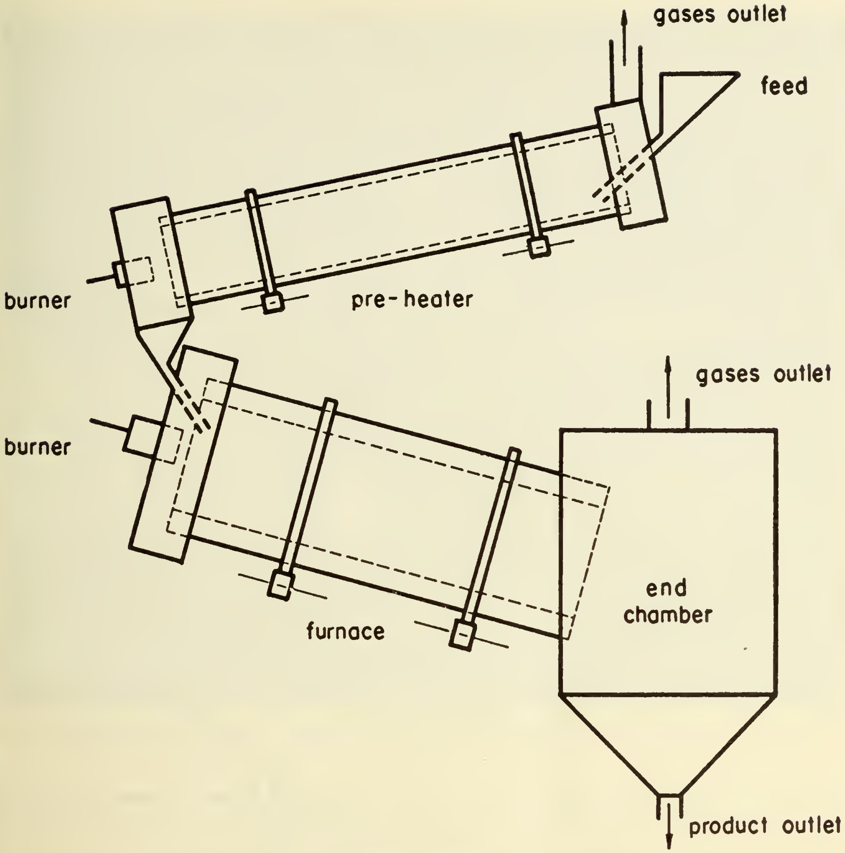

Figure 8. Pre-heater shown discharging into co-current rotary furnace.

of breakdown of the particles. Three beneficial effects of pre-heating are: (1) It reduces the combined water content and elevates the expansion temperature of the glass, with greater effect on the fines than on the coarse particles; (2) it diminishes the effect of thermal shock which might occur when cold glass hits the hot flame, especially with perlites having many fracture planes; and (3) it heats the larger particles to nearer the temperature required for expansion, thereby making them more likely to expand when they receive a short flash of high temperature. Over-pre-heating should be avoided, as this may deaden the glass so much that it will later fail to expand to the desired degree. Another effect of even slightly too much pre-heat is a soft product consisting of heavy fines and light, over-melted coarse particles.

A pre-heater usually consists of a steel tube set at a very slight angle to the horizontal, rolling on trunions at a speed of 5 to 15 r.p.m. It may be anywhere from 6 inches to 2 feet in diameter, and 4 to 20 feet long. Some are unlined, but in the interests of good capacity and fuel efficiency, most are lined with a steel or alloy tube, or with a refractory lining. The flame may be either co-current or counter-current to the flow of crude perlite. It is good practice to prevent the flame in the pre-heater from coming in contact with the perlite.

BURNERS AND COLLECTION SYSTEMS

Burners. Although most perlite furnaces use gas as a fuel, the growth of the perlite business in the east, where low-cost gas is not available, has created a demand for an oil-fired furnace. Two commercially available furnaces can be equipped with dual-fuel or oil burners. Another type can only burn fuel oil indirectly after first vaporizing it by hot air into a gas. Many burners suitable for firing boilers or tunnel furnaces cannot be used for expanding perlite, as dropping a ton of sand per hour into a flame tends to extinguish combustion. Therefore a fairly well-mixed gas-air mixture must be used, or in the case of oil, a finely atomized oil-air dispersion. Use of a burner tunnel to radiate heat onto the flame just in front of the nozzle is also helpful in maintaining combustion. It is usually found desirable to proportion the fuel to the air rather accurately throughout the range of fuel consumptions employed.

Collection Systems. All of the furnaces described above deliver the gases and material to an end-chamber of one kind or another, in which most of the product is separated out from the gases, leaving only 10 to 30 percent suspended in the gases which are discharged from the

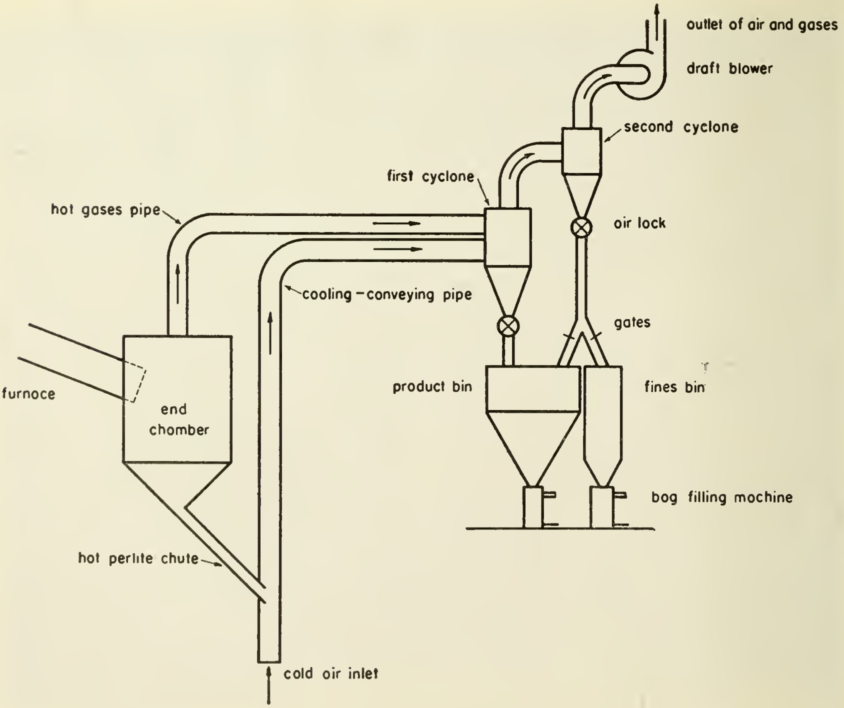
outlet of air and gases
draft blower
second cyclone
first cyclone
hot gases pipe
air lock
cooling – conveying pipe
gates
furnace
end chamber
product bin
fines bin
bag filling machine
hot perlite chute
cold air inlet

FIGURE 9. A collection system for a perlite processing plant.

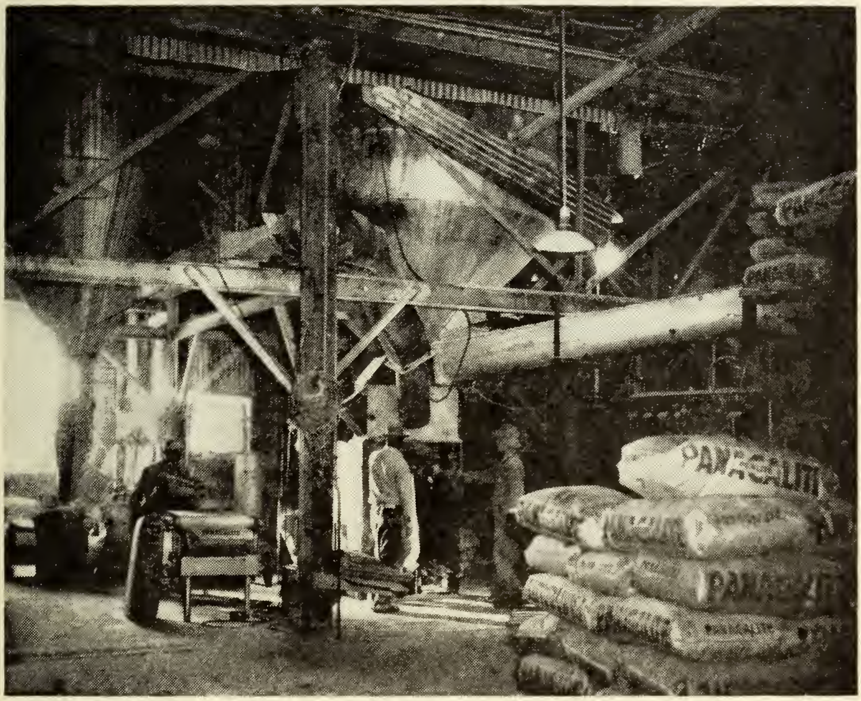

FIGURE 10. Interior of American Perlite Corporation plant, Richmond, California. *Photo by C. W. Chesterman.*

top of the end-chamber. The purpose of a collection system is to cool the main product and transport it to the point where it is to be bagged, and to remove the major part of the material carried off in the gases, transporting it to the bagging point, where it is either recombined with the main product or bagged off separately. In some plants, an elevator or a screw carries the main product into a bin for bagging. This type of system does not provide enough cooling capacity for a high production unit. Also, fused pieces, unexpandable impurities, fire-brick, and tramp iron become mixed with the product. Air conveying of the main product has proven to be the most successful way of handling it, because (1) it provides more cooling than any other method, (2) it separates foreign matter from the product, and (3) it offers great flexibility in the relative location of the furnace and bagging point. Improperly designed air conveying systems, however, can cause a break-down of the perlite particles, particularly when a soft, poorly furnaced product is being conveyed.

The product may be dropped out of the end chamber into a suction pipe, and carried through a 7- to 20-inch pipe to a cyclone collector which is kept under a vacuum of a few ounces by a fan sucking on it. The product drops out of the cyclone through an air lock, which prevents air from rushing up into the cyclone and spoiling its efficiency. The hot gases from the end chamber may be conducted either into the same cyclone as the product, or into a separate cyclone. This second cyclone can discharge directly into the same bin as the main product, into a separate bin for bagging as fines, or into the same suction pipe as the end chamber product. Sometimes instead of sucking the product into the collection cyclone, it is blown under pressure, using an air lock or a venturi to make the product drop from a suction point in the end-chamber to a pressure point in the conveyor system. A wet washer or bag house may be used at the end of the collection system to reduce to a very minimum the amount of dust blown out into the air. However, both of these devices have been found to be much more costly to maintain than a cyclone. Two or more cyclones in series are sometimes used, the first cyclone having lower efficiency than the following ones, so as to air-separate the product into several size fractions.

MINES AND MINERAL RESOURCES OF SACRAMENTO COUNTY, CALIFORNIA

By Denton W. Carlson *

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ABSTRACT

Sacramento County lies at the southern end of Sacramento Valley, 90 miles east of San Francisco and within the Great Valley and the Sierra Nevada geomorphic provinces of California. The provinces differ markedly from one another in their geographic and geologic characteristics. Most of the county lies within the Great Valley province, which is characterized by an alluvial plain and consists principally of a thick accumulation of sediments ranging in age from Cretaceous to Recent. Low rolling foothills of the Sierra Nevada rise from the plain in the eastern part of the county, where Logtown Ridge metavolcanic rocks and Mariposa slate, both Upper Jurassic in age, are exposed.

The value of the total recorded mineral production of the county for the period 1880-1951 is $240,552,353. Of the 58 counties in California, Sacramento County ranked eighth in 1951 in value of mineral production. The value of mineral commodities produced in 1951 including natural gas, sand and gravel, gold, clay, silver, platinum, and stone was $22,264,560.

The major portion of California's largest natural gas field, the Rio Vista field, lies within Sacramento County. Natural gas output in the county during 1951 was valued at $14,608,866, a figure that ranked Sacramento County as the second natural gas producing county in the State.

Sacramento County's sand and gravel production has risen consistently since World War II; in 1951 amounted to $4,012,848. In 1951 also, sand and gravel displaced gold as the second most valuable mineral commodity in the county and amounted to 7 percent of California's total output, clearly indicating the importance of Sacramento County as a center of sand and gravel production.

Gold has been mined from this county since 1849. Successful bucket-line dredging began in 1899 in the Folsom area. The bucket-line dredges have contributed most of the gold production of the county, although gold has been recovered from dragline dredges, hydraulic and drift mines, and small-scale placer mines. In 1953 the Natomas Company, the leading gold producer in California, was operating five connected bucket-line dredges in the Natomas area. During 1951, $3,205,475 in gold were produced. Some gold is recovered as a by-product of sand and gravel operations while minor amounts have been obtained from a few lode mines.

Clay processing plants in the county consume appreciable quantities of clay and clay soil. Some clay is imported from adjacent counties, but most of it is obtained from deposits near Michigan Bar. Clay soil is obtained from the Sacramento area. Sacramento County clay production amounted to $59,811 during 1951.

In past years, substantial amounts of granitic rocks have been quarried in the Folsom area, particularly from the Folsom State Prison quarry. Since 1946 there has been no recorded production from the county.

Previous to 1889, sandstone was quarried in the vicinity of Michigan Bar and used in building construction in Sacramento. Molding sand was produced for a number of years previous to 1950 in North Sacramento and consumed in the county. Platinum and silver are by-products from gold dredging operations.

The southwestern tip of the county lies in an area that contains the largest known reserves of peat in California. Because this land is some of the richest agricultural land in the State, peat and peat products have not been exploited.

Lignite, a low-grade coal, is known to underlie certain portions of eastern Sacramento County, but no attempt has been made to recover it.

INTRODUCTION

Geography. The Sacramento River, the main drainage for Sacramento Valley, in which Sacramento County lies, forms the western boundary of the County from upper Suisun Bay to a point about 15 miles north of Sacramento, the capitol of California. The county border then extends eastward to the American River, about 4 miles northeast of Folsom, and thence southward to Dry Creek which forms a good portion of its southern boundary. About 12 miles west of Galt, the border trends southwestward to upper Suisun Bay at the confluence of the Sacramento and San Joaquin Rivers.

The long narrow strip of land in the southwestern part of the county is barely above mean sea level. Consequently, this area, commonly known as the delta region, would be periodically inundated except for the many levees that have been constructed, converting it into one of the most highly productive farming districts in the world.

The western part of the county is only about 30 feet above sea level, and Sacramento, as well as other adjacent communities, is protected by levees and by-passes along the Sacramento and American Rivers.

History. A route for hunters and trappers was made through what is now Sacramento County by Jedediah Strong Smith in 1828, after several Spanish expeditions had searched for mission sites. But it was not until 1839 that the first white settlement was established by a Swiss immigrant, Captain John A. Sutter, who constructed a large adobe fort at the confluence of the Sacramento and American Rivers. Captain Sutter received a land grant of 11 leagues from the governor of California, Alvarado. During the ensuing years, a settlement known as New Helvetia developed around the fort.

In the years following establishment of Sutter's Fort, Captain Sutter amassed a fortune from stock raising and wheat. In 1848, in order to supply an increasing demand for lumber, he assigned James W. Marshall the task of locating and building a lumber mill. Marshall established the mill on the South Fork of the American River at what is now known as Coloma, about 35 airline miles northeast of Sacramento. The discovery of gold in the mill tail race presaged the now legendary California gold rush. As a result of this, Sutter was ruined financially, inasmuch as his men deserted him in the mad rush for gold.

Soon thereafter, Sutter's son laid out a new town on the river bank and named it after the river, Sacramento. The Sacramento River had been named earlier by the early Spanish explorer Moraga in honor of the Holy Sacrament.

By 1850, Sacramento County had a population of 9000 and was admitted during that year as one of California's original 27 counties. In 1854 the State Capitol was established at Sacramento, and in 1860, this city was the western terminus for the famed Pony Express. Sacramento was connected to the east by rail when the last spike of the Central Pacific Railway was driven in 1869.

Population. The population of Sacramento County in 1950 was 275,760, a 62 percent increase over 1940. The California Department of Finance estimated that the population of the county was 336,700 as of July 1, 1953.

Industries. Agriculture, the most important industry of Sacramento County, contributed slightly over 48 million dollars worth of products during 1950. The value from field crops, which include tomatoes, alfalfa, hops, sugar beets, barley, pears, and rice, ranked first in dollar value, followed by livestock and dairy products, fruit, nuts and berries, vegetables, and poultry. During 1951, mineral products valued at $22,264,560 were produced in the county. Food processing plants are the predominant manufacturing industry in the county.

GEOLOGY

The major part of Sacramento County lies in the Central or Great Valley of which the northern half is commonly designated as the Sacramento Valley. Sacramento Valley is an alluvial plain formed partly by river erosion and partly by river deposition. It is drained by the Sacramento River system whose tributary streams, the American and Cosumnes, drain Sacramento County. The eastern fringe of the county is dotted by rounded low hills or low, flat-topped buttes which are part of the foothills of the Sierra Nevada. In general the county has low relief and elevations range from slightly below sea level in marshlands bordering the Sacramento River to slightly more than 600 feet on the higher buttes.

Rock Formations. In the western part of the county, which lies wholly in the valley, exposed rocks are either alluvial sand, gravel and clay of Recent age deposited by the Sacramento River system, or are similar alluvial and alluvial terrace deposits of Pliocene and Pleistocene age. East of these Quaternary river deposits, patches of fluviatile Pliocene and Miocene rocks, composed predominantly of volcanic debris, may be crossed successively until the bedrock units of the Sierra Nevada are reached in or near the Sierran foothills. Small patches of marine Eocene and Upper Cretaceous rocks appear near the Sierran foothills from beneath the younger deposits where they have been exposed by Recent streams. Erosion has also exposed small patches of Eocene river channel deposits, which once were buried by younger Cenozoic deposits. These also are confined to the strip bordering the Sierra Nevada.

The bedrock of the Sierra Nevada is made up of strongly folded, northwest-trending metasedimentary and metavolcanic rocks of Paleozoic and middle Mesozoic age intruded by a variety of serpentinic and granitic rocks of Jura-Cretaceous age. As the metamorphic rocks of the bedrock complex were strongly folded by unequal compressive forces acting from the northeast and southwest, they tend to dip northeast at steep angles. Upon the upturned edges of these old crystalline rocks the flat or gently dipping late Cretaceous and Cenozoic rocks have been laid so that they overlap the Sierra Nevada along its western border.

Within the borders of Sacramento County the basement metamorphic rocks are either slates and phyllites of the Upper Jurassic Mariposa formation or are massive green metavolcanic rocks and green schists derived from andesitic or basaltic parent rocks. In this part of the Sierra Nevada these are generally regarded as being of Upper Jurassic age, but some may be Paleozoic as well. Farther south, Jurassic greenstones form one of the upper members of the Amador group (Taliaferro, 1943, pp. 282-283) and the member is called the Logtown Ridge formation. The Logtown Ridge formation consists of submarine flows, tuffs and agglomerate of augite andesite. The tuffs commonly have been recrystallized into amphibole and chlorite schists. Small amounts of welded tuff, tuffaceous sandstone and slate are interbedded with volcanic material in this formation. The Logtown Ridge formation has been observed to grade upward into the Mariposa formation. (Taliaferro, 1943, p. 284).

The Upper Jurassic Mariposa formation crops out in a series of lenticular belts interfolded with Jurassic metavolcanic rocks. The formation consists predominantly of black clay-slate with minor amounts of sheared sandstone and conglomerate. Locally, volcanic rocks are present in the Mariposa formation, evidently the result of submarine volcanism. (Taliaferro, 1943, p. 285). Although not generally fossiliferous, some marine mollusks have been found in scattered localities. Fossils have been found in the formation in Sacramento County only at White Rock station (Lindgren, 1894, p. 3) on the Southern Pacific Railroad.

Granodiorite and related granitic rocks have intruded pre-Cretaceous metavolcanic and mestasedimentary rocks in several patches in the eastern part of the county. They were emplaced during late Jurassic or early Cretaceous time. These rocks generally have a gray cast produced by a matrix of grayish white quartz and feldspars sprinkled uniformly with black biotite or hornblende or both. Granitic rocks have been utilized intermittently for paving blocks, monuments and similar products.

Upper Cretaceous rocks, exposed chiefly in the Folsom area, consist of soft, light-brown to greenish-brown sandstone and siltstone containing some conglomeratic strata. Marine mollusks are abundant in most parts of the sequence. The exposed thickness of Cretaceous strata northwest of the American River bridge at Folsom is 25 feet. Outcrops 3-4 miles northwest of Folsom probably do not exceed 50 feet (Davis and Olmstead, 1953, p. Ku 4, 5).

Early Tertiary rocks are represented in Sacramento County chiefly by the middle Eocene Ione formation, although Oligocene strata crop out a little farther north in Placer County and one mass of fossiliferous marl of possible lower Eocene age crops out 8 miles south of Folsom (Davis and Olmstead, 1953, p. Te 9). The latter mass is believed to be part of the Meganos formation. The Ione formation consists principally of friable to well-indurated massive quartz-anauxite sandstone, white, anauxitic, kaolinite-type clays and clayey sandstone. Pebbly and bouldery strata are locally present as well as some black lignite. Red and reddish-brown, highly ferruginous sandstone is characteristically present in thin strata, particularly above basement or above beds of low permeability. Recent geologic mapping by Turner (Pask and Turner, 1952, pp. 13, 16-20) shows that in some parts of the Sierran foothills the Ione formation is divisible into two members separated by an unconformity and otherwise recognizable by mineralogical differences in the clays. The Ione formation is an exceedingly important source of high-grade clay and silica sand.

Middle Tertiary rocks lie disconformably on the Ione formation in the places where they are in contact. The lowermost formation in this predominantly pyroclastic group of rocks is the Valley Springs formation of middle (?) Miocene age. The Valley Springs assemblage consists chiefly of rhyolite tuff, tuffaceous clay and tuffaceous conglomerate commonly containing well-defined glass shards and fragments of pumice. The sandy parts of the formation resemble the Ione formation from which they were derived and are discernible principally by the presence of volcanic debris. Disconformably above the Valley Springs formation is the Mehrten formation, parts of which are probably upper Miocene and parts of which are lower Pliocene. In Sacramento County the Mehrten formation consists predominantly of well-bedded fluviatile deposits composed largely of hornblende andesite debris. Locally there are mud-flow, breccia and tuff facies. Excellent exposures of the Mehrten formation are visible along the north bank of the American River west of Folsom.

Above the middle Tertiary rocks of predominantly volcanic character is a series of fluviatile sand, gravel, clay and mixed deposits of Plio-Pleistocene age. These contain debris derived chiefly from the Bedrock complex of the Sierra Nevada. Debris from earlier Tertiary volcanic and sedimentary rocks is present but seldom predominates. These rocks have been separated into a number of units and given names such as the Laguna formation and Arroyo Seco gravel. In some places these units are readily divisible into lithologic units, but elsewhere they are not readily separable and relationships are obscure. In general the oldest unit, the Laguna formation, and to a slightly lesser extent, the other Plio-Pleistocene units, contain a much larger proportion of strongly weathered material than the later Quaternary units. The Arroyo Seco gravel commonly is stained red by iron oxide coatings on the grains. An excellent exposure of the Laguna formation may be seen on the north bank of the American River just east of the bridge at Fair Oaks. Good exposures of the Arroyo Seco gravels may be seen half a mile northeast of Elk Grove. Arroyo Seco gravels generally form a slightly unconformable capping above the Laguna formation. The terraces generally occupy positions suggestive of an age intermediate between that of the Arroyo Seco gravels and Victor formation.

The Pleistocene Victor formation is also a river floodplain deposit that has been slightly dissected and whose base rests upon an erosion surface formed after deposition of the Arroyo Seco gravels. The debris making up the deposit varies widely, both vertically and laterally, the material being poorly sorted, poorly rounded, crudely stratified and largely unweathered. Hardpan layers representing buried clay-soil zones occur at various depths below the surface but most commonly within 6 feet of the surface. Rocks of the Victor formation generally are unconsolidated except where clayey and silty layers have attained firmness by compaction. Sand and gravel of the Victor formation are important sources of aggregate in Sacramento County.

Recent alluvium has been derived by present stream systems and included channel deposits, floodplain and terrace deposits and natural levees. Peat becomes admixed in swamp areas. Artificial levees have confined contemporary alluviation chiefly to the network of main channels and sloughs. Sands and gravels taken from Recent river channels are also important sources of aggregates.

Structure. The Great Valley is a structural trough as well as a topographic basin. Bedrock along the eastern border of the valley consists of pre-Cretaceous metamorphic rocks which have been intruded by granitic rocks of the Mesozoic Sierran batholith. The bedrock surface, which is exposed along the eastern border of the Great Valley, dips gently westward and is overlain by an increasingly thick prism of marine and continental sediments. Bedrock along the western border of the valley is generally considered to be weakly metamorphosed rocks of the Franciscan group (Upper Jurassic?), the base of which has not been found. The configuration of the Franciscan surface is not well known and relationships between the bedrock on the east and the bedrock on the west have not been well established. Wells have not penetrated bedrock in the deepest part of the structural trough. The axis of the structural trough or geosyncline, although not well located, lies close to the western border of the Great Valley.

Quaternary alluvium covers the major area of the floor of the Great Valley but the bevelled edges of Tertiary and Cretaceous rocks are exposed to a limited extent on the east and west margins of the valley. Gentle west-dipping homoclinal strata overlap the bedrock surface beneath the eastern half of the valley. Under the western half they become more completely folded and the predominant synclinal structure is modified by minor folds and by subsurface faults.

Cretaceous-Cenozoic sediments probably attain a thickness of at least 11,000 feet. Few test holes have penetrated the entire Cretaceous and very few holes have exceeded 10,000 feet in depth.

Summary of Geologic History and Mineral Deposition. During the late Paleozoic era and probably continuing into the Upper Jurassic epoch, an extensive inland sea covered what is now Sacramento County. Rocks of this geologic time, which crop out in counties east of Sacramento County, are the marine meta-sediments of the Calaveras group (Carboniferous and Permian).

The oldest rocks exposed in Sacramento County are those of the Logtown Ridge formation of the Amador group, which were deposited as a result of sub-marine volcanism during the early part of the Upper Jurassic epoch. At the close of this Amador volcanism, continued deposition of non-volcanic silts and clays formed the later Upper Jurassic Mariposa formation.

In late Jurassic or early Cretaceous time, the marine basin was destroyed by a crustal disturbance of great magnitude. The nearly flat-lying Mesozoic and Paleozoic sediments were folded into a complicated series of folds and the sediments themselves were changed under influence of heat and pressure into metamorphic rocks. Thus the ancestral Sierra Nevada was elevated and developed as a fold-mountain range.

Before this folding, deep-seated ultrabasic igneous rocks (peridotites) were intruded into the marine sediments in the deeper parts of the geosyncline. During this episode chromite was segregated from the peridotite as well as minute quantities of platinum. These peridotites which have been largely altered to serpentine, crop out just east of Sacramento County.

Following the basic intrusions and accompanying and following the folding, granitic rocks were intruded on a major scale, followed by hydrothermal deposition of gold, copper and zinc. This gold was the original source of virtually all the placer gold in Sacramento County.

A period of extensive erosion followed throughout most of Cretaceous time which stripped the rocks lying above the gold deposits and cut deeply into the gold-bearing veins themselves. This resulted in the formation of the earliest gold-bearing placers. Just prior to the beginning of the Tertiary period, the Upper Cretaceous sea advanced eastward and occupied the present Great Valley as far as the western foothills of the Sierra Nevada. Thin, relatively flat-lying fossiliferous marine deposits were laid down on the folded eroded bedrock surface. Some natural gas in Sacramento County is now obtained from sediments that were deposited at this time. In this county small patches of Upper Cretaceous deposits are exposed in the Folsom area.

Erosion continued into the early Tertiary period and by Eocene time, the Sierra Nevada had become deeply eroded and a subtropical climate had developed. Under the influence of reduced elevations and humid climate, chemical decay of the bedrock proceeded slowly but deeply. The finer products of this erosion, such as quartz sand and clay, were transported by water and deposited along the margin of the Eocene sea, thus giving rise to valuable clay, quartz sand, and lignite deposits (Ione formation). A favorable environment for the formation of large natural gas deposits also developed at this time.

At or near the end of the Eocene epoch, volcanism broke out and reached a peak in middle Miocene time. Immense quantities of rhyolite ash were deposited which deeply mantled what is now the western flank of the Sierra Nevada. As a result, the drainage pattern which existed at that time was drastically altered. The pre-volcanic stream channel deposits, rich in placer gold, were buried or mixed with the new volcanic stream deposits. Consequently, these inter-volcanic stream deposits were found to be lean in placer gold.

By late Miocene or early Pliocene time, volcanic activity reached a second peak when massive flows of andesite and large volumes of fragmental andesitic material were erupted. It was during this time that the area now occupied by western Sacramento County was probably covered by a sea while the eastern part of the county was characterized by a gently west-sloping volcanic plain.

Continued erosion of the volcanic plain from late Miocene to the Recent epoch, which was aided by the major re-elevation of the Sierra Nevada by faulting and tilting in late Pliocene and Quaternary time, resulted in deposition of the Laguna, Arroyo Seco, and Victor units. Three major alluvial plains developed successively during the Pliocene and Pleistocene, the Laguna, Arroyo Seco, and Victor. Deposition of the Victor formation gave rise to valuable sand and gravel deposits.

Continued stripping of gold lodes in Pleistocene and Recent times enriched the present stream channels with placer gold. Introduction of the Recent epoch saw the development of river floodplain clay soil deposits as well as sand and gravel deposits and the final development of the present climate and topography.

MINES AND MINERAL RESOURCES

Sacramento County's total recorded mineral production, 1880-1951, is valued at $240,552,353. During 1951, natural gas, sand and gravel and gold were the three most important mineral commodities produced. Table 1 shows the mineral production of Sacramento County, 1880-1951.

Clay and Clay Processing

During 1951, 20,687 short tons of clay valued at $59,811 was produced in Sacramento County. Most of this production, together with some clay from other counties, was consumed by processing plants in this county in manufacture of clay products, including bricks, hollow building tile, flower pots, chimneyware, drainage and sewer pipe, and adobe bricks.

Between 1877 and 1896, there was a large demand for common bricks, not only locally, but in San Francisco as well. During this period, a brick industry developed and flourished in Sacramento County, although the exact recorded production of brick previous to 1911 is lacking.

The availability of raw material, clay soil, and cheap water transportation to the then largest market, San Francisco, contributed to the development of the county's brick industry. As other building materials began to be substituted for and to compete with common bricks in the building and construction industry, the demand for common bricks decreased until by 1906, only the Sacramento Transportation Company brick plant was in operation (Aubury 1906, p. 253).

The decreasing market for bricks was accompanied by an increasing market for other clay products in the late 1890's and early 1900's. As a result, diversification in the clay industry began and by 1906, three companies were engaged in manufacturing various clay products including butter jars, churns, flower pots, sewer pipe, terra cotta chimneyware and firebricks. Crude clay at that time was obtained from deposits in Sacramento and Amador Counties.

By 1915, several different firms were manufacturing various clay products, including bricks, pottery, and sewer pipe, (Waring 1919, pp. 402-404). The increasing market for common bricks and other clay products since 1915 has resulted in the development of a substantial present-day clay and clay processing industry in Sacramento County.

At the present time, raw materials utilized by the clay and clay processing industry are obtained from deposits in Sacramento and Amador Counties. In Sacramento County, clay from the Eocene Ione formation in the vicinity of Michigan Bar is exploited. One clay deposit 3 miles southwest of White Rock is the weathered product of Upper Jurassic Mariposa slate. This clay is shipped to a processing plant in San Jose, California. Hardpan or caliche and clay soil are exploited in the vicinity of the Sacramento metropolitan area.

Cannon and Company (Sacramento Clay Products Company). Location: Plant is located near North 13th Street and East El Camino Avenue in North Sacramento. Clay pits are located at the plant and in the vicinity of Michigan Bar in secs. 1 and 2, T. 7 N., R. 8 E., M.D.M. Ownership: Cannon and Company, Box 802, Sacramento 4, California. Mrs. M. L. Fulcher is general manager and Mr. E. Castro is plant superintendent.

The history of Cannon and Company began about 1910 when the Silica Brick Company began operations (M. L. Fulcher, personal communication, 1953). Some time before 1916, the name became the Sacramento Clay Products Company. Following 1916, the holdings of the Sacramento Clay Products Company were acquired by the Cannon Phillips Company and by 1920 the company was known as Cannon and Company (Boalich and others, 1920, p. 91). The operation has con-

Table 1. Mineral production in Sacramento County, 1880-1951.

Year	Gold, value	Silver, value	Platinum		Brick		Sand and gravel	
			Ounces	Value	M	Value	Short tons	Value
1880	$342,514	---	---	---	---	---	---	---
1881	425,000	$1,000	---	---	---	---	---	---
1882	400,000	---	---	---	---	---	---	---
1883	480,000	---	---	---	---	---	---	---
1884	270,000	---	---	---	---	---	---	---
1885	353,522	---	---	---	---	---	---	---
1886	280,000	---	---	---	---	---	---	---
1887	158,526	176	---	---	---	---	---	---
1888	150,000	---	---	---	---	---	---	---
1889	210,075	---	---	---	---	---	---	---
1890	193,585	---	---	---	---	---	---	---
1891	142,830	4	---	---	---	---	---	---
1892	121,900	---	---	---	---	---	---	---
1893	90,091	---	---	---	---	---	---	---
1894	70,326	---	---	---	11,250	$56,250	---	---
1895	145,873	---	---	---	13,125	65,625	---	---
1896	133,050	---	---	---	8,700	44,200	[10]	---
1897	93,050	---	---	---	3,100	16,700	[10]	---
1898	57,301	---	---	---	11,000	44,000	[10]	---
1899	115,906	---	---	---	15,600	93,600	[10]	---
1900	176,007	[2]473	---	---	8,900	53,400	[10]	---
1901	229,034	[2]253	---	---	12,236	62,180	[10]	---
1902	425,894	330	---	---	10,492	78,198	[10]	---
1903	335,646	234	---	---	15,000	120,000	[10]	---
1904	419,287	75	---	---	4,500	20,000	[10]	---
1905	668,382	206	40	$700	18,000	130,000	[10]	---
1906	986,624	3,640	11	200	12,000	108,000	[10]	---
1907	790,973	2,034	---	---	16,078	128,624	[10]	---
1908	1,166,055	1,621	---	---	7,936	63,491	[10]	---
1909	1,669,814	2,856	---	---	---	---	[10]	---
1910	1,396,874	4,606	---	---	---	---	[10]	---
1911	1,812,826	3,047	---	---	13,017	76,571	133,660	13,366
1912	1,712,587	3,544	---	---	26,073	161,535	138,977	12,662
1913	2,503,633	3,406	---	---	22,535	144,191	250,164	48,551
1914	2,164,491	3,481	223	7,108	22,862	160,923	321,473	36,685
1915	2,131,813	3,151	196	6,217	9,920	82,973	207,802	40,321
1916	1,833,855	3,578	195	8,892	8,924	91,615	138,108	36,404
1917	1,919,581	4,487	157	12,453	and tile	122,886	140,137	30,753
1918	1,694,724	4,637	[3]	---	---	79,312	119,512	53,683
1919	1,714,193	5,276	[3]	---	[3]	---	[6]75,428	49,103
1920	1,575,033	4,534	[3]	---	---	248,433	[9]260,039	140,990
1921	1,690,662	5,254	[3]	---	---	216,402	159,216	137,014
1922	1,350,749	3,392	---	---	---	259,263	[6]157,233	96,425
1923	1,331,227	2,566	[3]	---	---	327,636	[6]295,335	215,343
1924	1,150,687	1,753	---	---	---	290,213	[6]350,021	217,159
1925	1,302,320	1,920	---	---	---	354,078	[8]392,742	228,552
1926	1,304,046	1,627	---	---	---	388,697	[7]470,725	257,879
1927	1,211,278	1,472	---	---	---	295,677	[6]460,843	455,594
1928	1,558,173	1,779	[3]	---	---	295,669	[6]530,615	364,531
1929	1,492,083	1,583	[3]	---	---	228,312	335,522	184,591
1930	1,724,712	1,313	---	---	---	195,807	207,899	141,648
1931	1,871,195	1,056	144	5,876	---	151,539	[6]208,921	128,189
1932	2,100,250	1,120	[3]	---	---	85,187	[6]132,608	70,313
1933	2,996,669	1,768	[3]	---	---	75,081	[6]88,493	55,971
1934	3,555,468	2,940	[3]	---	---	40,572	[6]173,861	136,482
1935	3,983,985	3,163	[3]	---	---	77,562	[6]131,632	96,095
1936	3,660,125	3,283	[3]	---	---	116,453	265,710	195,544
1937	3,660,765	3,359	[3]	---	---	[3]	[6]305,247	208,438
1938	4,973,640	4,031	[3]	---	---	[3]	[6]402,378	234,515
1939	5,374,935	5,104	[3]	---	---	[3]	[6]297,385	217,111
1940	5,538,295	7,076	[3]	---	---	[3]	381,303	191,612
1941	6,287,575	7,276	[3]	---	---	[3]	[6]550,278	401,195
1942	4,379,200	4,542	[3]	---	[3]	---	[6]921,202	706,283
1943	565,460	576	[3]	---	[3]	---	[6]672,593	602,672
1944	832,615	795	---	---	---	---	[6]1,221,694	870,460
1945	1,149,785	1,073	---	[3]	---	[3]	[6]783,645	633,900
1946	3,509,625	4,326	---	[3]	---	[3]	1,210,514	822,279
1947	3,974,600	5,614	---	---	---	[5]340,000	1,564,464	1,334,108
1948	4,135,320	5,875	---	[3]	---	[5]368,000	1,453,173	1,353,347
1949	3,702,160	4,466	---	[3]	---	---	1,322,605	1,228,163
1950	3,435,320	4,064	---	[3]	---	---	1,176,310	1,066,924
1951	3,205,475	3,689	---	[3]	---	---	3,577,191	4,012,848
Total	$118,569,274	$148,890	---	---	---	$6,358,855	21,986,658	$13,314,855

Table 1. Mineral production in Sacramento County, 1880-1951—Continued.

Year	Granite		Natural gas		Miscellaneous stone,[1] value	Miscellaneous and unapportioned		
	Cu. ft.	Value	M cu. ft.	Value		Amount	Value	Substance
1880	--------	--------	----------	----------	----------	----------	----------	
1881	--------	--------	----------	----------	----------	----------	----------	
1882	--------	--------	----------	----------	----------	----------	----------	
1883	--------	--------	----------	----------	----------	----------	----------	
1884	--------	--------	----------	----------	----------	----------	----------	
1885	--------	--------	----------	----------	----------	----------	----------	
1886	--------	--------	----------	----------	----------	----------	----------	
1887	--------	--------	----------	----------	----------	----------	----------	
1888	--------	--------	----------	----------	----------	----------	----------	
1889	--------	--------	----------	----------	----------	----------	----------	
1890	--------	--------	----------	----------	----------	----------	----------	
1891	--------	--------	----------	----------	----------	----------	----------	
1892	--------	--------	----------	----------	----------	----------	----------	
1893	--------	--------	----------	----------	----------	----------	----------	
1894	75,000	$35,000	----------	----------	----------	----------	----------	
1895	85,000	45,000	----------	----------	----------	----------	----------	
1896	--------	--------	----------	----------	[1]$12,108	----------	----------	
1897	207,845	62,339	----------	----------	[1]28,074	----------	$1,500	Pottery clay.
1898	4,840	4,000	15,000	$12,000	[1]14,137	----------	----------	
1899	1,524	1,145	12,000	10,000	[1]13,105	----------	----------	
1900	2,137	3,139	11,750	11,750	[1]14,157	----------	----------	
1901	2,635	2,882	----------	----------	[1]7,926	----------	316	Copper.
1902	288	136	38,550	31,200	[1]19,380	----------	----------	
1903	20,471	2,222	31,680	30,518	[1]18,176	----------	----------	
1904	5,164	4,458	39,200	39,200	[1]22,103	----------	----------	
1905	4,327	1,614	43,564	43,564	[1]32,386	----------	----------	
1906	10,905	1,779	60,225	52,874	[1]18,141	----------	----------	
1907	26,105	4,625	60,225	52,874	[1]13,936	----------	----------	
1908	44,151	44,151	55,000	55,000	[1]151,477	----------	----------	
1909	31,660	23,745	60,000	60,000	[1]235,210	----------	314,438	Unapportioned, 1900-09.
1910	68,684	59,947	49,203	49,203	[1]164,592	----------	----------	
1911	45,630	2,307	9,000	83,890	117,671	----------	----------	
1912	--------	--------	100,000	96,000	185,111	----------	----------	
1913	--------	--------	72,000	36,000	189,925	----------	----------	
1914	--------	--------	80,000	40,000	216,550	----------	----------	
1915	--------	--------	108,000	54,000	243,806	----------	----------	
1916	--------	--------	[3]	----------	158,314	227 lbs.	16	Lead.
						----------	46,000	Pottery, clay, natural gas.
1917	--------	--------	[3]	----------	169,086	----------	27,000	Other minerals.
						310 tons	410	Pottery clay.
1918	--------	--------	[3]	----------	209,006	----------	61,235	Natural gas, platinum, potash.
1919	--------	--------	[3]	----------	227,629	----------	113,000	Clay and clay products.
						----------	61,395	Natural gas and platinum.
1920	--------	--------	[3]	----------	39,573	----------	57,591	Natural gas and platinum.
1921	--------	39,469	[3]	----------	249,897	----------	56,196	Natural gas and platinum.
1922	--------	51,500	----------	----------	316,242	----------	111,991	Natural gas and platinum.
1923	--------	30,740	[3]	----------	434,596	----------	93,907	Natural gas and platinum.
1924	--------	11,150	[3]	----------	422,652	1,750 tons	4,470	Clay (pottery).
						----------	98,126	Natural gas, platinum.
1925	--------	155,250	[3]	----------	361,807	----------	2,748	Clay (pottery).
						----------	97,730	Natural gas, platinum.
1926	--------	7,812	[3]	----------	180,207	1,528 tons	2,310	Clay (pottery).
						----------	101,374	Natural gas, platinum.
1927	--------	33,600	[3]	----------	298,612	----------	52,683	Clay (pottery), natural gas, platinum.
1928	--------	19,658	[3]	----------	89,244	----------	60,591	Clay (pottery), natural gas, platinum.
1929	--------	6,726	[3]	----------	279,339	----------	54,713	Clay (pottery), lead, natural gas, platinum.
1930	--------	7,751	[3]	----------	222,547	----------	27,330	Clay (pottery), natural gas, platinum.
1931	--------	12,316	[3]	----------	77,158	----------	12,345	Clay (pottery), lead, natural gas.
1932	--------	--------	[3]	----------	65,231	----------	17,822	Clay (pottery), natural gas, platinum.
1933	--------	--------	[3]	----------	26,631	----------	16,643	Copper, lead, natural gas, platinum.
1934	--------	[3]	[3]	----------	96,812	----------	45,483	Copper, lead, granite, natural gas, platinum, paving blocks.
1935	--------	--------	[3]	----------	146,742	----------	29,216	Natural gas, platinum.
1936	--------	--------	[3]	----------	253,829	3,141 lbs.	147	Lead.
						----------	25,304	Copper, natural gas, platinum.
1937	--------	--------	[3]	----------	305,261	----------	112,866	Brick and hollow tile, natural gas, platinum.
1938	--------	--------	[3]	----------	141,644	----------	113,657	Brick, granite, natural gas, paving blocks.
1939	--------	--------	[3]	----------	141,446	----------	117,001	Brick, clay, granite, natural gas, platinum, paving blocks.
1940	--------	--------	[3]	----------	89,168	----------	102,683	Brick, clay, granite, natural gas, platinum.

Table 1. Mineral production in Sacramento County, 1880-1951—Continued.

Year	Granite		Natural gas		Miscellaneous stone,[1] value	Miscellaneous and unapportioned		
	Cu. ft.	Value	M cu. ft.	Value		Amount	Value	Substance
1941	--------	--------	4,005,707	355,397	302,048	----------	130,510	Brick, clay, copper, lead, granite, petroleum, platinum, paving blocks.
1942	[3]	--------	49,172,104	3,937,671	719,502	----------	137,548	Brick and hollow tile, clay (pottery), granite, paving blocks, platinum.
1943	[3]	--------	62,766,484	4,767,138	479,755	----------	173,397	Brick and hollow tile, clay (pottery), granite, platinum, paving blocks.
1944	--------	--------	72,644,058	5,490,344	519,767	----------	118,706	
1945	--------	[3]	88,406,045	6,736,811	543,208	----------	176,103	Brick and hollow tile, clay (pottery), granite, platinum.
1946	--------	--------	81,027,875	8,639,377	549,381	----------	296,502	Brick, hollow tile, pottery clay, platinum.
1947	--------	--------	72,883,000	8,357,000	375,438	----------	56,384	Raw clay and other minerals.
1948	--------	--------	81,791,000	10,874,000	[3]	----------	369,383	Raw clay, platinum and stone.
1949	--------	--------	72,670,000	10,315,000	236,042	----------	58,291	Clay, platinum.
1950	--------	--------	90,756,000	12,667,000	[3]	----------	182,457	Platinum, stone.
						31,606 tons	34,817	Clay.
1951	--------	--------	77,706,733	14,608,866	[3]	----------	373,871	Platinum, stone.
						----------	59,811	Clay.
Total	--------		[3]754,674,403	$87,506,677	$10,445,785	----------	$4,208,017	

—Notes at end of table

[1] Includes crushed rock, rubble, rip-rap, paving blocks.

[2] Recalculated to *commercial* from *coining value* as originally published.

[3] See under *Unapportioned.*

[4] State Prison use, value estimated, as none reported.

[5] Includes clay products, heavy clay other than pottery and refractories.

[6] Includes molding sand.

[7] Includes molding sand and special plaster sand.

[8] Includes molding sand and roofing gravel.

[9] Includes foundry, molding, and core sand.

[10] See under *Miscellaneous stone value.*

tinued steadily to the present time. The company produces clay products, brick and hollow building tile and crude clay.

Red and white fire clay is mined from the Ione formation in the vicinity of Michigan Bar and hardpan is mined from a pit at the plant. At the Michigan Bar deposits in secs. 1, 2, and 11, T. 7 N., R. 8 E., M.D.M., the clay is generally mantled by an average of 4 feet of sand, gravel and soil overburden. In some places where the overburden has been removed by early-day hydraulic mining and by erosion, parts of the clay deposit are exposed. Hardpan, which is mined at the plant, averages 6 feet in thickness under 2 feet of topsoil.

The hardpan is drilled, blasted, and trucked about 200 yards to the plant. A combination power shovel-dragline is used for stripping and mining operations at both the hardpan and clay deposits. At the Michigan Bar pits, clay stockpiles are maintained from which trucks are loaded by a traxcavator for the haul to the plant. Stockpiles of both the clay and hardpan are also maintained at the plant.

From the yard stockpiles of clay and hardpan, the material is trucked about 200 yards to the plant. The raw products fall into a chute to a tooth-roll crusher and are raised to a horizontal belt conveyor by means of a bucket elevator. The crushed products fall into separate piles beneath the belt conveyor. The north pile consists of crushed hardpan and the three south piles consist of red, white, and yellow clay.

Between the north and south piles are two dry-pan grinders. One of these grinders processes white and red clay only. Processed white clay is sacked and marketed to the mortar industry as ''Cream Mortar.'' Processed red clay is also sacked and marketed as ''G-3 Mud,'' which is used as a well-drilling mud.

The second dry-pan grinder is used to blend clay and hardpan from which clay products are made. The fineness of grind and the clay constituents blended depend upon the product being manufactured. After grinding, the material is raised by a bucket elevator and passed over a dry vibrating screen, which may range in size from No. 6 to No. 12. The undersize falls into the first storage bin while the oversize is reground. From the first storage bin, the material is delivered into a second storage bin by means of augers and another bucket elevator. This second bin discharges by gravity directly into a pug mill. A ''dry-mud'' or ''stiff-mud'' process is used, so that only a little moisture is added to the clay in the pug mill. The pug mill discharges into the extruding machine. The extrusion dies are changed for the different types of clay product being made, such as face brick or hollow tile. The desired cross-section of the material is extruded on a cutting table where it is wire cut to standard lengths.

The product is then dried by waste heat from the four down-draft kilns which are exhausted by two fans and a series of connecting underground tunnels. For solid brick, a burning period of 115 to 125 hours is required. For hollow tile and patio tile, a period of from 72 to 90 hours is required. The kilns are fired from gas furnished by the Pacific Gas and Electric Company.

The Michigan Bar pits are operated during the dry season each year. The plant operates throughout the year, one shift per day, five days per week. A normal crew consists of 30 men.

H. C. Muddox Company. Location: 30th and L Streets, in Sacramento. Ownership: Mrs. Jesse E. Muddox. J. D. Pearson is the company manager.

The H. C. Muddox Company began clay operations in 1877 under the name of the Capital Sewer Pipe Works (Watts 1890, p. 509). At that time the company was manufacturing sewer pipe, stoneware, fire brick and terra cotta ware.

Between 1906 and 1915, the company name was changed from the Capital Sewer Pipe Works to the Muddox Pottery Company, and by 1925, the company name had again been changed to the H. C. Muddox Company. The company now manufactures drainage, chimney, and sewer pipe.

Raw material consists of local topsoil and white clay from Ione, Amador County. The raw material used is a mixture of approximately 50 percent topsoil and 50 percent clay. The mixed topsoil and clay is ground in wet pans, then sent to a steam-operated, sewer-pipe press.

From the sewer-pipe press, the shapes are hand trucked to the drier, where they remain from 2 days to 2 weeks, depending on the weather. After initial drying, the shapes are burned in one of six beehive kilns for a week to 10 days. The kilns range in capacity from 28 to 45 tons.

This operation is continuous throughout the year. A normal crew consists of 23 men.

Harrison Fait. Location: sec. 27, T. 9 N., R. 5 E., M.D.M. (projected), 1.6 miles south of Highway 40 on Howe Avenue, 4 airline miles northeast of Sacramento. Ownership: Harrison Fait, 1950 Howe Avenue, North Sacramento, California.

The production of adobe bricks by Harrison Fait began in August 1946 and has continued steadily to the present time. The mixing plant, which operates about 25 days per year, has a rated capacity of 40 tons per hour of wet adobe mud. Under normal conditions, the operation produces 1500 adobe bricks per hour.

Adobe bricks are made from clay-soil, sand, and an emulsion consisting of asphalt and water mixed to proper proportions. During the first few years of operation, clay soil was obtained from the plant site, although in recent years it has been hauled from building excavations at close proximity to the plant.

The clay-soil and sand are stockpiled and kept damp with sprinklers, then cultivated to near-powder fineness before being processed in the plant. A carry-all loader is used to transport the material from the stockpile to the plant. The prepared clay-soil and sand are sent to a roll crusher by means of a bar-feeder and inclined belt conveyor. After crushing, the clay soil and sand are conveyed to the mixer. Water and an emulsion which consists of approximately 60 percent asphalt and 40 percent water, are added to the crushed clay soil and sand and thoroughly mixed in the mixer. The capacity of the mixing plant is about 200 standard size bricks, measuring 4 by 7½ by 6 inches, per batch of mud.

The clay is molded in a machine mounted on wheels. The machine then places the molded bricks in rows on strips of paper on the ground. Each row of bricks is covered with paper to prevent them from drying too rapidly. Curing time for the bricks ranges from 18 to 30 days, depending on size of the bricks and the weather.

Four sizes of adobe bricks are produced; 4 by 16 by 3½ inches, 4 by 16 by 5½ inches, 4 by 16 by 7½ inches, 4 by 16 by 12 inches. A normal crew consists of six men.

Panama Pottery Company (Sacramento Pottery Company). Location: 442 24th Street Road, Sacramento. Ownership: N. R. and O. G. Leonard. Roy Campbell is plant foreman.

The principal product of this company is red flower pots ranging from 1 to 16 inches in diameter. The manufacture of pottery ware began in 1913 and this plant, although rebuilt several times since then, has operated intermittently to the present time. The plant has burned down three times since 1913, the last fire having occurred in 1945. At that time the present owners purchased the plant and since then have been operating it continuously.

The raw materials used in this operation are from clay deposits near Michigan Bar in Sacramento County and Ione in Amador County. Five tons of clay are consumed daily at this plant.

A blend of red clay (28 to 30 percent alumina content), white clay (30 to 35 percent alumina content), and clayey soil are mixed with water in the proportion of four parts clayey soil to five parts red and white clay. This mixture, called "slip," is screened by a 24-mesh screen and filtered. The filtered mixture is further mixed in a pug mill and then extruded in cylindrical shapes. Sawdust is usually added to the material to give the finished product the desired porosity. The shapes are molded by machine into flower pots.

The flower-pot shapes are placed on trays in a drier for 24 hours of initial drying. The pots are then baked in one of two beehive kilns where they remain for nine days. During this time the temperature is gradually increased and decreased, reaching a maximum temperature of 2000° F.

The principal market for the red flower pots is nurseries. Flower pots from this plant are marketed in California, other western states, and the Hawaiian Islands.

Sacramento Brick Company (Riverside Brick Yard) Pit. Location: secs. 27 and 34, T. 8 N., R. 4 E., M.D.M., (projected), on Riverside Road 5½ miles southwest of Sacramento. The brick plant is located alongside of the Sacramento River about a mile northwest of the pit. Ownership: Sacramento Brick Company and leased to a partnership consisting of L. Harrison and M. O'Leary of Sacramento.

This plant has been active since about 1879 at which time it was operated by the Sacramento Transportation Company's Riverside Brickyard (Watts 1890, p. 506). The present operators, who leased the plant and pit in 1949, manufacture common red bricks for the Sacramento and northern California market. Operations are seasonal, usually beginning May 1 and terminating in the middle of October each year. Approximately 190 tons of clay are consumed daily during the operating season.

The deposit consists of gray clay-silt soil. The clay soil, ranging from 14 to 16 feet in thickness is underlain by sand strata and hard pan. There is no overburden present. The pit has an areal extent of about 30 acres and contains about 7 feet of water.

Clay is mined and stockpiled at the pit during the fall and allowed to drain and dry until the following year, when it is hauled to the brick plant. During the operating season, a 1½-yard Bucyrus Erie dragline loads the dry stockpiled clay, which was mined the previous year, into five four-ton side dump ore cars. The ore train is trammed by a dinky gasoline locomotive about a mile to the brick plant.

At the brick plant, the ore cars deposit the clay through a grizzly onto an inclined conveyor belt. The material is roll-crushed, screened, mixed in a pug mill, discharged from an extruder and cut to appropriate lengths by a revolving wire brick cutter. The shapes are then placed on small flat cars and hand trammed into the drier. After initial overnight drying, the bricks are burned in one of nine open-draft field kilns for 5 days. The kilns contain 650,000 bricks each.

Thirty five to 50 men are employed at this operation.

White Rock Pit. Location: sec. 30, T. 9 N., R. 8E., M.D.M., 6 miles southeast of Folsom. Gladding Brothers Manufacturing Company, South Third and Keyes Street, San Jose 12, California, has worked the property intermittently for about 19 years.

Western Refractories Company, a subsidiary of Gladding Brothers Manufacturing Company, mines clay from this pit. The raw clay is shipped by rail to San Jose where it is used by the parent company almost entirely in sewer pipe mixes with clays from Lincoln in Placer County.

A residual clay at this deposit is the weathered product of Upper Jurassic Mariposa slate. The slate has weathered to a white, buff, and red iron-stained clay. Some of the slate has retained its original black color although the outer edges of some hand specimens are almost entirely altered. Throughout the rest of the pit the slate has been completely changed to a dense plastic clay with very little sandy material. Relict schistosity in the pit strikes N. 30° W., with vertical dip (Turner, 1949). Overburden consisting of deep red Ione clay and gravel mantles the clay deposit from 6 inches to 3 feet in thickness.

Mining of the clay is only done during the summer months. Power shovels load onto trucks which transport the crude clay to the railroad at White Rock, 3 miles east of the pit. The material is then shipped by rail to San Jose, California.

Clay From Gold Dredging

As a result of bucket dredging for gold, fine silt and clay commonly known as ''slickens'' may settle in basins between large masses of waste gravel. During the years of dredge operation in the Natoma district, many millions of tons of clay have been segregated in this fashion. The individual basins are trough-shaped, and are generally less than 30 feet deep, ranging from 75 to 100 feet wide at the surface. The sides of the troughs are formed by boulder piles on an angle of repose of approximately 45 degrees, or by vertical banks of unmined gravel. Some of the basins are more than a mile and a half in length. Much of the clay area has been prospected by hand augers, and in one summer's prospecting alone, over 6,500,000 tons were proved (Logan and Dietrich, 1928, p. 186).

Tests have shown that water in the dredge ponds during dredging operations carry 6 to 10 percent solid material so fine that little of it is coarser than 200 mesh (Logan 1925, p. 3).

The first attempt to exploit these clays was by the Natoma Clay Company during the summer of 1926 on Alder Creek, a mile south of Natoma. Operations were suspended in 1927.

It was not until 1949 that another attempt was made to work this type of clay deposit. During that year, the California Art Tile Company of Richmond, California, began open-pit mining operations at a locality 0.4 mile southeast of Alder Creek at a station on the Southern Pacific Railroad 3 miles southwest of Folsom (M. D. Turner, 1949, unpublished report). This type of clay was used by the company primarily for coloring clay products, and, to a lesser extent, mixed with Ione red clay for certain ceramic products. All of the crude clay from this operation was shipped by rail to Richmond, California. This operation ceased in 1949.

Coal (Lignite)

There is no record of coal (lignite) having been produced in Sacramento County. Lignite is part of the Ione formation which is exposed in eastern Sacramento County. Watts (1892, p. 335) stated that a rancher in the eastern part of the county, 4½ miles northwest of Carbondale, had penetrated lignite beds to a thickness of about 9 feet in several wells on his ranch. An 85-foot shaft sunk for water also penetrated a 9-foot lignite bed at the bottom. The log of the sediments of this shaft is as follows:

Reddish sandy loam	3 feet
Red clay	3 "
Reddish gray sand	16 "
Hard, whitish sand rock	13 "
Grayish sand rock, softer	38 "
Soft black clay	5 "
Coal	9 "
Hard, blackish clay.	

Gold

From 1880 to 1951, $118,569,274 worth of gold was produced in Sacramento County. This figure represents about 73 percent of the total mineral wealth produced in the county. In 1951, $3,205,475 in gold was produced, representing about 13 percent of the mineral wealth produced in that year. This production ranked Sacramento County second in gold production in California. Since World War II, the gold from Sacramento County for each year has represented between 23 and 28 percent of California's total gold output.

Lode Mines

Lode mining has been practiced in Sacramento County intermittently since gold rush days but production from mines of this type has been small. Recent activity in connection with the lode-gold deposits was during the depression years of the early 1930's and to a lesser extent, during the early 1950's. The quartz veins that contain gold are found cutting Mariposa slate and green metavolcanic rocks and are not found in rocks of late Cretaceous age or younger. Dioritic and basic volcanic dikes have also been mineralized by gold-bearing solutions; gold-bearing quartz veins and stringers commonly are associated with basic dikes. Although a majority of quartz veins have been emplaced in fissures parallel to the northwest trend of the regional structure, crossing fissures in many cases have also been mineralized. Vein intersections commonly are centers of mineral deposition. Ore shoots in veins of Sacramento County tend to be pockety but some of the pockets have proven to be rich. According to Logan (Logan, 1925, p. 16) a shallow shaft yielded over $8,200.00 from a narrow shoot only 30 feet long.

Evanis Mine (Broder Ranch). Location: sec. 32, T. 10 N., R. 8 E., M.D.M., 3 miles east of Folsom. Ownership: Ida Evanis estate, Folsom, California.

During 1931, several small lots of ore from this mine averaging $16 in gold per ton were shipped to the Selby smelter (Heikes 1933, p. 659). The property was idle from the early 1930's until the summer of 1953, when the mine was leased by the Evanis Mining Company, a partnership composed of W. E. Paine, L. L. Dixon and E. Bloyed of Folsom, California. This company erected a new headframe, hoist, and a 25-ton stamp mill but no ore was mined. Operations were terminated in November, 1953. The property is now idle.

Some gold and pyrite occur in a small quartz vein that strikes east and dips about 70 degrees south. Country rock is meta-andesite of the Logtown Ridge formation.

There are three shafts on the property. Two of the shafts are caved or filled but the main shaft is open to a depth of 40 feet.

The mill consists of a Universal jaw crusher, five 1250-pound Risdon stamps with mercury traps, amalgamating plate, Knudsen bowl and a Wilfley table.

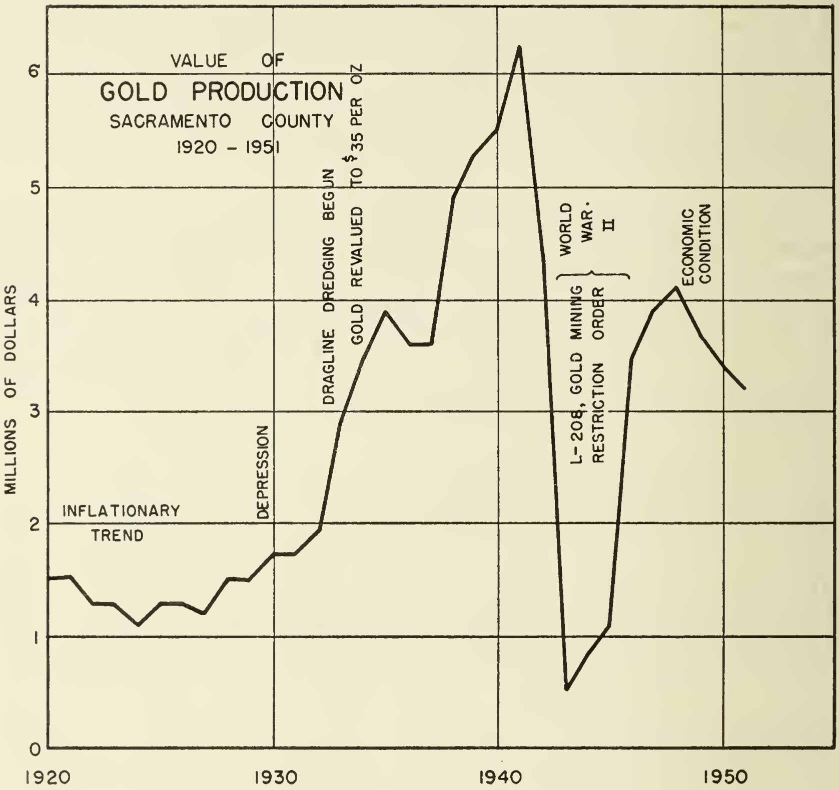

FIGURE 1. Value of gold produced in Sacramento County, 1920 to 1951.

Placer Mines

Geology of the Gravels

Gold-bearing gravels worked in Sacramento County are found chiefly near the bases of certain of the Plio-Pleistocene terraces or else near the contact of the Laguna formation and the underlying Mehrten formation. Paying gravel so far has not been found in either the Plio-Pleistocene Arroyo Seco gravel or in the Mehrten formation. The Recent stream channels, worked by hand placering methods during gold rush days, have also been worked in later years by dredges and in isolated instances by hydraulicking. Dredges have been responsible for a major proportion of the gold production of Sacramento County and Sacramento County has contributed materially to the total gold production of the State. The gold now found in the gravels was released during destruction of the upper parts of numerous quartz veins of the lode-gold belt in the process of erosion of the Bedrock complex of the Sierra Nevada—from Cretaceous to Recent time. Gold deposited in the early Tertiary gravels in part was handed on through erosion and redeposition to the later Tertiary and Quaternary gravels, but the major part of the gold now mined probably was derived by direct erosion and deposition from the adjacent lode-gold belt. In recent years some gold has been recovered as a by-product of sand and gravel operations.

Bucket-Line Dredges *

The first successful connected bucket-line gold dredge to be commissioned in Sacramento County was installed in the Folsom area in April, 1899 (Waring, 1919, p. 408). This dredge was put into operation by the Colorado Pacific Gold Dredging Company and was the forerunner of many dredges that have since operated in Sacramento County. The Natomas Company, which is the result of many early-day gold dredging company mergers, including the Colorado Pacific Gold Dredging Company, is the only remaining gold dredging company now operating in Sacramento County.

Crawford (1894, p. 226) describes the Doan Mining dredger as a grab-dredger which began operating in the bed of the American River at Natoma in July, 1894. The grab dredger, which was erected on an 18-by-30-foot scow, was steam operated and had a capacity of 500 tons per 24 hours. The gravel was dug by a grabber, classified on a one-inch screen and the gold was recovered in sluices equipped with riffles and blankets. No mention of this operation is to be found in subsequent publications and it is assumed that this venture proved unsuccessful.

Today's principles of dredging differ little from those that were instituted in dredges that were designed and built in the period from 1899 to 1906. Auriferous gravel, recoverable by dredging, must be dug, screened, washed, and the metal saved, and waste disposed of in tailing piles.

The first bucket-line dredges in the county had wooden super-structures, wooden hulls that were 70-110 feet by 29-50 feet by 6-7½ feet deep. These early dredges were equipped with digging buckets ranging in capacity from 3¼ to 7½ cubic feet per bucket. The bucket-line dredges

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* Most of the production figures given in this section were taken from the *Minerals Yearbook* for various years.

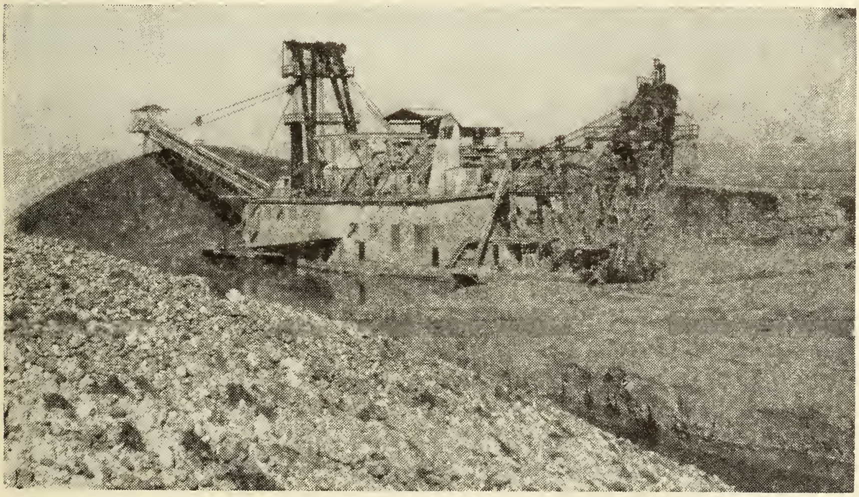

FIGURE 2. Natomas Company's No. 6 connected bucket-line dredge. This dredge digs to a depth of 75 feet below the water level and handles 4,000,000 cubic yards of auriferous gravel per year.

Active Natomas Company Dredges in Sacramento County, December 15, 1953.

Dredge no.	Year started	Hull dimensions			Bucket capacity (cu. ft.)	Number buckets on ladder	Digging depth below H_2O	Re-covery methods	Approx. yearly yardage
		Length	Width	Depth					
1	1935	114′-0	54′-0	11′-0	16	61	30′-0	jigs & riffles	4,500,000
5	1937	149′-4	58′-0	11′-0	11	107	65′-0	jigs & rifflles	4,000,000
6	1938-49 moved 1951–	154′-8	58′-0	11′-0	11	116	75′-0	jigs & riffles	4,000,000
8	1937	149′-4	58′-0	11′-0	11	107	65′-0	jigs & riffles	4,000,000
10	1912	150′-0	56′-0	10′-6	18	88	65′-0	jigs & riffles	4,000,000

now in operation, are primarily of all-steel construction, including the hulls whose dimensions are 114-155 feet by 46-58 feet by 9½-11 feet deep. These present-day dredges are equipped with digging buckets with cubic-foot capacities ranging from 11 to 18. The early bucket-line dredges had a capacity of around 65,000 cubic yards per month, while those of today in this county have a capacity of approximately 340,000 cubic yards per month.

A bucket-line dredge floats in a pond which moves along with the dredge. The gravel is constantly excavated by the endless chain of moving buckets. Digging is started at the top of the bank and as the bucket-line moves upward, the dredge swings to the left and right, pivoting about the spud, a heavy pole at the stern with its point imbedded in rock tailings. The side swinging is accomplished by port and starboard bow lines which are carried from the underwater end of the digging ladder to shore blocks and back to the bow fair-leads on the forward deck, thence to the swing winch, usually mounted inside the deck house on the starboard side.

The buckets elevate the material to a main hopper ahead of a revolving trommel. The gravel is washed and classified in the trommel. Trommel oversize or tailings are discharged to a rubber conveyor belt or so-called stacker belt where the material is stacked astern of the dredge as large tailing piles. The tailings left by bucket-line dredges consist of huge furrow-like ridges of gravels, cobbles and small boulders, which are 50 feet or more above the adjacent land surface.

Trommel undersize, which is usually minus ½-inch, falls to launders equipped with riffles with quicksilver traps or to vibrating tables. Free gold readily amalgamates with quicksilver and is cleaned up periodically, usually at weekly intervals, and retorted ashore.

In recent years, jigs of one type or another have either been substituted as a complete recovery system, or they are used in conjunction with tables and riffles. Tailings from the gold-saving system flow into the pond behind the barge.

All of the Natoma dredges are electrically operated and most of them convert AC power to DC power on board.

Dragline Dredges *

Dragline dredges were developed and put into operation in California during 1933. These dredges worked gravels in which the gold content of the deposit would not amortize the capital investment of a bucket-line dredge. See the tabulated list for information on the many dragline dredges which have operated in Sacramento County since 1933.

A dragline dredge is composed of two separate and distinct units: a dragline excavator and a floating or nonfloating washing plant. The digging is accomplished by a dragline excavator which travels on the ground by means of caterpillar tracks under its own power. The dragline is equipped with a bucket of from 1 to 3 cubic-yard capacities and with booms 50 feet in length.

The dragline discharges to a washing plant which is either mounted on a barge or on tracks. The material is first deposited into a hopper ahead of a trommel where the gravel is washed and classified. Oversize from the trommel is stacked in tailings piles astern of the washing plant by means of a stacker belt.

The trommel undersize passes to inclined sluices equipped with riffles to retain the gold. Tailings from the riffles flow into the pond.

Capital Dredging Company. The Capital Dredging Company, a subsidiary of Yuba Consolidated Gold Fields, maintained a field office on the road between Mills Junction and White Rock, 4½ miles west of White Rock, and operated dredges in Sacramento County continuously from 1927 to the latter part of 1952.

Dredging operations commenced in 1927 when one dredge was commissioned in the Natomas Field 5 miles south of Folsom. By 1930, three electrically-powered dredges, two of which were equipped with 151 9-cubic-foot buckets and one with 88 18-cubic-foot buckets, were recovering placer gold, silver, and some platinum. During 1931, 7,967,354 cubic yards of gravel were washed and in 1935, the amount of material washed by the three dredges had increased to 9,963,620 cubic yards.

From 1940 until October 1942, two dredges, No. 3 and No. 4, both of the connected-bucket type, were in operation until they were closed down in compliance with the war-time limitation order, L-208.

Resumption of dredging operations on their property 5 miles south of Folsom began on October 8, 1945, when their No. 3 Yuba dredge, which was equipped with 100 18-cubic-foot buckets, was put back into operation. In 1948, dredge No. 4 was also re-activated. Due to rising costs, dredge No. 3 was shut down and dismantled in December 1950. The company's No. 4 dredge operated until it was shut down in July 1952 and was then moved to Marysville, California.

Cosumnes Gold Dredging Company. Location: Field office located at the site of the old town of Sebastopol, Sacramento County, in sec. 12, T. 7 N., R. 7 E., M.D.M. (projected). Ownership: Cosumnes Gold Dredging Company, G. M. Standifer, president, 465 California Street, San Francisco, California.

A connected-bucket type gold dredge was put into operation seven miles southwest of Sloughouse during the last quarter of 1936 by the Cosumnes Gold Dredging Company. This company dredged in the

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* Most of the production figures given in this section were taken from the *Minerals Yearbook* for various years.

Cosumnes River district on the high terrace deposits south and east of the Cosumnes River continuously from 1936 until October 20, 1942, when the dredge was shut down. Dredging operations were resumed during the latter part of 1947 and continued steadily until 1951. The company has been inactive in Sacramento County since 1951. During 1938, 3,411,337 cubic yards of gravel were handled which yielded 10,018 ounces of gold.

The company dredge was electrically powered and equipped with 63 12-cubic-foot buckets. The dredge was capable of digging 28 feet under water and of maintaining a 14-foot bank. It operated at an average rate of 250,000 cubic yards per month. The average number of men employed was 25.

Garibaldi Dredge. C. R. Garibaldi of Sutter Creek, California, operated a dragline dredge on the Ryan, Stanton, and Van Vleck properties on the Cosumnes River just east of Bridge House from February 1948 to 1950. This land was partly dredged by the Humphreys Gold Corporation between 1940 and 1942.

The gravel deposit which was worked to about 30 feet in depth contained a considerable amount of red clay. This deposit was similar to the gravel worked extensively by hydraulicking in the vicinity of Michigan Bar. The deposit was underlain by the Ione formation.

A dragline equipped with 1-¾ cubic yard, heavy duty bucket was used. A bench was cut four to six feet deep and the dragline delivered the gravel to a floating Bodinson washing plant. The washing plant had a total of 132 linear feet of side sluices and 80 feet of tail sluices. Coarse tailings were stacked by a 55-foot belt conveyor and were removed at frequent intervals by a Caterpillar tractor and bulldozer.

All power was furnished by diesel engines. Water was pumped from the Cosumnes River which flowed nearby the operations to the north. Three men were employed on one shift and about 100 cubic yards of gravel were washed per hour.

General Dredging Company. Location: Office at Natoma, California, in sec. 3, T. 9 N., R. 9 E., M.D.M. Ownership: General Dredging Company, Natoma, California.

The General Dredging Company began dredging operations under the name of the General Utility Corporation early in 1938. On October 27 of that year, the General Dredging Corporation took over operation of the washing plant and dragline and operated on the American River until the latter part of 1941. On September 30, 1941, the General Dredging Corporation was dissolved and renamed as the General Dredging Company, which was a partnership. During 1941 and 1942, the company operated three dragline dredges; No. 1 on the American River near Folsom, No. 2 on an ancient river channel near Natoma, and the No. 4 dredge on the American River near Fair Oaks. All dredges were closed down in late 1942.

In 1946, dredging was resumed on Alder Creek, 2½ miles south of Folsom, with a dragline dredge. This was on land leased from the Natomas Company. The gravels in Alder Creek were as thick as 25 feet although the average thickness was 18 feet. This operation continued steadily until March, 1951, when rising costs of labor and material forced the company to cease all active operations in Sacramento County.

The equipment used for dredging Alder Creek consisted of a 3-cubic-yard dragline excavator and a 36- by 38- by 4-foot deep electrically-powered floating Bodinson washing plant. The dragline delivered the auriferous gravel to a hopper located on the washing plant. Behind the hopper was a 5- by 36-foot trommel with $\frac{3}{8}$-inch perforations in the upper half and $\frac{1}{2}$-inch perforations in the lower half. The oversize went to an 80-foot stacker and the undersize went to a bank of 10 sluices which were located on each side of the trommel. The sluices were equipped with Hungarian riffles at the upper end and expanded metal riffles and cocoa matting at the lower end. The capacity of this dragline dredge was about 200 cubic yards per hour.

Eighteen to 20 men were employed in the Alder Creek operation.

Gold Hill Dredging Company. On April 10, 1933, the Gold Hill Dredging Company began operating a connected bucket-line dredge on the old Americanos Rancho about 3 miles southeast of Folsom. This dredge operated continuously from 1933 to March 21, 1937, at which time it was closed down. Some gold was produced in 1938 from the dredge clean-up operations and later during that year the dredge was moved to the Ophir district in Placer County.

During the first year of operation the company used an electrically-powered dredge equipped with buckets of 9-cubic-foot capacities. This equipment was thoroughly reconstructed, repaired, and modernized, and from 1934 to 1937 their dredge was equipped with 66 $7\frac{1}{2}$-cubic-foot buckets.

During each of the years from 1934 to 1936 this dredge handled about 2,000,000 cubic yards of auriferous gravel.

Hoosier Gulch Placers. Hoosier Gulch Placers conducted dredging operations in the Cosumnes River district from 1937 to 1942. In 1937 a dragline dredge began operating on Hoosier Gulch southeast of Sloughhouse. During 1940 a dragline dredge with a $2\frac{1}{2}$-cubic-yard dragline excavator worked on the Hutchinson property while a second dragline dredge with a 2-cubic-yard excavator operated on Katesville Gulch and on the Logtown property. Throughout 1941 and during part of 1942 the company operated boat No. 1 on the Biggs Ranch and boat No. 2 on the Rossi property in the Cosumnes River district.

Humphreys Gold Corporation. The Humphreys Gold Corporation operated a dragline dredge in the Cosumnes River district on the Fassett-Parker-Hanlon property from January 1 to December 5, 1940. At this time the equipment, which included a dragline excavator with a $2\frac{1}{2}$-cubic-yard bucket, was moved to the Hutchinson property where operations were continued during all of 1941 to April 6, 1942. Near the end of the last operation, the company's equipment consisted of five dragline excavators, each with $2\frac{1}{2}$-cubic yard buckets, three of which were used for stripping and two for delivering gravel to two washing plants. An average of 18 feet of overburden was sidecast and 12 feet of gravel and 1 foot of bedrock were washed.

Lancha Plana Gold Dredging Company. The Lancha Plana Gold Dredging Company, La Lomita Rancho, Lockeford, California, operated a dredge on the American River in the Folsom district from 1940 to April 8, 1949. From April 20, 1940 until November 1942 a Yuba dredge, electrically powered and equipped with 84 6-cubic-foot buckets, worked the gravels of Sailor's Bar on the American River. This dredge, which was called the company's No. 4 dredge was idle from November 1942 until October 22, 1945 when dredging was resumed on the American River eight miles south of Folsom. Since the latter part of 1945 the dredge operated continuously along the American River, moving upstream from Natoma towards the town of Folsom.

Mountain Gold Dredging Company. The Mountain Gold Dredging Company operated a dragline dredge in the Cosumnes River district from 1947 to October 22, 1950. From May 29 to December 31, 1947, gold was dredged from the Granless, Stanton, and Ryan properties. From 1948 to 1950 the company worked property at Michigan Bar, including the Van Vleck property. During 9 months of 1948 the company dredged 160,000 cubic yards of gravel which yielded 655 ounces of gold and 66 ounces of silver.

Natomas Company. Location: Field offices and repair shops are located at Natoma, California. The company is presently operating 5 bucket-line dredges in the county south of the American River and northeast of Mather Air Force Base. Ownership: Natomas Company, Forum Building, Sacramento. R. G. Smith, President and General Manager, Cyril Thomas, Manager, E. A. Foster, Chief Engineer, Calvin Sears, Superintendent of dredges.

The Natomas Company began in the Folsom area in Sacramento County on January 1, 1909. On this date, the Natomas Consolidated of California, one of the earlier names of the present-day Natomas Company, was formed from the consolidation of three separate gold dredging companies: the Folsom Development Company, the Natoma Development Company, and the El Dorado Gold Dredging Company. During 1908, the Natoma Development Company was formed from the consolidation of the Syndicate Dredging Company, Natomas Vineyard Company, and the Colorado Pacific Gold Dredging Company.

In 1916, the Natomas Consolidated of California absorbed the holdings of the Wilkes-Barre Dredging Company, which was the last remaining gold dredging company in the Folsom area during that year.

Between 1916 and 1919, the company name was changed from Natomas Consolidated of California to Natomas Company of California and the latter name was changed in 1928 to the Natomas Company.

In early 1943, after suspending all dredging operations late in 1942 in compliance with the War Production Board Order L-208, the Natomas Company was granted a permit to resume operations on a limited scale. Production was begun on February 1, 1943, and two of a fleet of seven bucketline dredges continued working without interruption throughout the war period. This operation was carried on under stringent restrictions with respect to labor and supplies. The inactive dredges proved a source of replacement when parts of the active dredges failed. During this time the labor force of the company included many men who were advanced in years and not serving in war plants.

By the end of 1945, five of the seven dredges were back in operation. For each of the years from 1946 to 1952, the Natomas Company was the leading gold producer in California.

At the present time the Natomas Company is operating 5 dredges in Sacramento County one to three miles east and northeast of Mather Air Force Base. The dredges are working in the Victor formation, late Tertiary and early Quaternary terrace gravels, and the underlying Laguna formation. Approximately 24 million cubic yards of gravel, which yielded about 11 cents per cubic yard, were handled during 1952.

Of the five operating floating connected-bucket dredges, dredge No. 6 is the largest. Its hull dimensions measure 154.8 feet long, 58 feet wide and 11 feet deep. All of the dredge hulls are structural steel compartmented hulls. Dredge No. 6 has 116 buckets, each with a capacity of 11 cubic feet. It is capable of digging to a depth of 75 feet below the water level and handles approximately 4,000,000 cubic yards of gravel per year.

Each of the five operating dredges has from 61 to 107 connected buckets which range from 11 to 18 feet in cubic-foot capacities. The full thrust from digging is absorbed by the spud, the largest of which is 65 feet long and weighs 40 tons. Some Natomas dredges make use of two spuds; either can be used for digging or they are both used alternately for stepping ahead. The buckets dig auriferous gravels and discharge into a hopper ahead of an inclined trommel. Each dredge is equipped with a 9- by 45-foot trommel which has ⅜-inch openings at the upper end and ½-inch openings at the lower end. The gravel inside the trommel is washed by high pressure water delivered through 1¼-inch nozzle from a 14-inch pump. The trommel oversize or plus ½-inch material goes to the tailings stacker and the undersize goes to a distributor. Equal flow of the undersize to each of two jig-launder systems, one on each side of the trommel, is regulated by the distributor. Each jig-launder system consists of eight Pan-American or Bendelari jigs ahead of double-deck launders. The launders, which have a slope of about 1 inch per foot, are fitted with iron-faced wooden riffles and mercury traps. The jigs have a bed of ¼-inch steel shot.

Concentrates from the jigs are discharged over a single launder with riffles and mercury traps. In order to save the gold which is too rusty to amalgamate, this launder discharge is elevated from a sump to a single jig, the concentrate from which goes to a 2- by 3-foot pebble mill in which the gold is polished. Pebble mill discharge flows into another launder equipped with riffles and mercury traps.

The following information on the economics of mining is from a 1952 stockholders report (this company includes data from their one active dredge in Nevada):

Item	*1951*	*1952*
1. Total cubic yards dredged	27,586,119	26,827,872
2. Gross per cubic yard	10.68¢	11.08¢
3. Operating cost per cubic yard	7.77¢	7.84¢
4. Depreciation and depletion per cubic yard	1.69¢	1.73¢
5. Royalties per cubic yard	0.18¢	0.34¢
6. Total cost per cubic yard	9.64¢	9.91¢
7. Net returns per cubic yard	1.04¢	1.17¢

For smoother action, both the port and starboard bow winches and the digging ladder drive on four of the dredges are powered by direct current electric motors. All other equipment is powered by alternating current motors. Electric power is purchased from the Pacific Gas and Electric Company.

Water for the dredge ponds is obtained from Salmon Falls, 12 miles northeast of Natoma on the South Fork of the American River. Transmission from Salmon Falls terminates in the Willow Hill reservoir which is 1½ miles southwest of Folsom. Distribution from this reservoir to the dredge ponds is by gravity through a network of canals. Willow Hill reservoir also provides water for irrigation on adjacent lands.

Drift Mines

Drift mining has practically ceased in Sacramento County, since few if any placer deposits left by the bucket-line and dragline dredges can be profitably worked by drift mining.

After the curtailment of hydraulic mining in 1884 and before the introduction of the bucket dredges in 1899, placer gold mining in Sacramento County was carried on in a small way by ground-sluice and drift-mining methods. Drift mining was applied chiefly to the exploitation of buried Tertiary river channels in the eastern part of the county, principally near Folsom. Old river channels in this area frequently contained considerable gold at or near the so-called volcanic ''bedrock'' but these deposits were generally covered by a thick mantle of unproductive material. Because virtually all of the drift mines in the county were small scale enterprises with limited capital, the miners would drift only on the rich pay streaks.

However, the use of the bucket-line dredges and the dragline dredges introduced in 1933, allowed much of this theretofore unproductive material to be mined economically. Consequently, many of the workings of the earlier drift mines in the county have been obliterated by these dredges.

During the period from the middle 1880's to 1900, the amount of gold produced in the county was inaccurately recorded. This is true partly because many persons of Chinese descent who were engaged in ground-sluicing and drift mining for gold, sold their gold to Chinese merchants and no information as to the amount obtained was available. Wells, Fargo, and Company's agent in Folsom during 1896 reported that the shipments from their office were valued at $12,000 to $20,000 per month. The estimate of the gold not passing through the express office was placed at 20 percent of the total amount (Crawford, 1896, pp. 316-317).

About 40 men were working the Rebel Hill drift mines in 1889 (Watts, 1890, p. 510). The gravel was hauled to water and washed through sluices, rockers, and toms. In 1894, six drift mines in the Folsom area were active (Crawford, 1894, pp. 225-227), and eight drift mines were active in 1896 (Crawford, 1896, pp. 316-318). These mines were worked principally by vertical shafts down to about 60 feet in depth and by drifts and crosscuts. The auriferous gravel was then brought to the surface and washed in sluices where the gold was recovered.

In 1916, the Gray Mining Company operated the Gray drift mine near the head of Alder Creek, at the old ''Rhodes Diggins,'' three miles southeast of Folsom in the NW¼ sec. 18, T. 9 N., R. 8 E., M.D.M. Gold was recovered from blue gravel on a slate bedrock and the channel was thought to trend north-south and to be about 50 feet wide and 4,000 feet long (Waring, 1916, p. 413). The 40-foot shaft is now caved.

In 1925, the Buckeye Flat Mining Company operated their drift mine on the bank of Alder Creek near Natoma (Logan, 1925, p. 15).

Some work was done during 1935 on the Blue Ravine drift mine which is located 4 miles northeast of Folsom, near Mormon Island. This mine had apparently been idle since 1896 at which time the Hart Mining Company sunk a 60-foot shaft to "bedrock". (Crawford, 1896, p. 316).

The Gray Wing Extension Mining Company opened the Gray Wing Extension drift mine in 1932 on the old Broder ranch east of Folsom and in 1933 recovered $44,546 in gold (Bradley, 1935, p. 21). Some exploratory drilling was done in 1934 but operations were suspended in April, 1935. During the four-month period of operation during 1935, 800 tons of material were handled which yielded a small quantity of gold. Development consisted of a 98-foot shaft.

Hydraulic Mines

Hydraulic mining, a specialized outgrowth of placer mining employs jets of water under high pressure directed against banks of gravel through large nozzles called giants or monitors. Gravel so disrupted is then washed in the same fashion as in placer mining. Hydraulic mining, which began in 1852, was an extremely important means of producing gold in California prior to 1884, when a court decree known as the Sawyer Decision practically eliminated all hydraulic mining in California.

In Sacramento County, the auriferous gravels of the Eocene Ione formation in the Michigan Bar-Sloughhouse area were hydraulicked rather extensively. The Michigan Bar hydraulic mines were situated on the Cosumnes River and had been worked for many years prior to 1896 (Crawford, 1896, p. 317). Some hydraulic mining was also done in the Folsom area. Since the late 1890's, however, there has been no hydraulic-mining activity in Sacramento County.

Granitic Rock

Granite (actually granodiorite and related granitic rocks) quarrying began in Sacramento County in the Folsom area about 1878 (Ireland, 1888, p. 557), but since 1931, only small and sporadic amounts have been produced. From 1946 to 1951, there was no recorded production of granite from this county. During 1952 and 1953, the American River channel below the Folsom Dam site was deepened and enlarged. The quarried granite was utilized in the earth-filled dams in conjunction with the Folsom Dam Project.

Quarried granite from the Folsom area has been used for cobblestone paving of the streets in San Francisco, street curbs, cemetery work, dam construction (Ireland, 1888, p. 557), railroad fill (Watts, 1890, p. 511), and prison buildings at the Folsom State Prison (Waring, 1919, p. 418).

The largest granite quarry is on the Folsom State Prison grounds where convict labor was utilized. This quarry has not produced any granite since 1943.

Natural Gas

The major portion of the Rio Vista gas field, California's largest natural gas field, is located in Sacramento County. In 1951, 77,706,733 Mcf of natural gas valued at $14,608,866 were produced in Sacramento

Mt. Diablo-South Sacramento Valley Correlation Chart

EPOCH		Rio Vista gas field west of Midland fault*			Rio Vista gas field east of Midland fault*			Thornton gas field*		River Island gas field**
PLIOCENE	UPPER		Laguna	Post-Eocene sediments predominantly non-Marine—usually not differentiated in wells		Laguna	Post-Eocene sediments predominantly non-Marine—usually not differentiated in wells	Post-Eocene sediments predominantly non-Marine—undifferentiated in wells		Sands and shales of continental orgin
	MIDDLE									
	LOWER									
MIOCENE	UPPER		Mehrten Cierbo?			? Mehrten Cierbo?				
	MIDDLE									
	LOWER									
OLIGOCENE										
EOCENE	UPPER	Markley group	Sidney Sh. Markley Sd. Nortonville or "Emigh" Sh.		Markley group	Sidney Sh. Markley Sd. Nortonville or "Emigh" Sh.		Markley group (undiffer.)		Markley formation Nortonville formation
	MIDDLE	Domengine Formation	"Green Sd." "White Sd." or "Emigh Sd." Clays		Domengine Formation	"Green Sd." "White Sd." or "Emigh Sd." Clays		Domengine Formation	? "Green Sd." "White Sd."	Domengine formation
	LOWER	Capay Sh.			Capay Sh.			Capay Sh.		Capay Shale
		Margaret Hamilton Sd.			? ↑			"Capay sand" or "Capital sand"		Meganos formation
		Meganos "C" Sh. Anderson Sd.			Midland Sd.			Meganos-Martinez (undiffer.)		
PALEOCENE					↓ ?					Martinez formation
		Martinez Sh.			Martinez Sh.					
CRETACEOUS	UPPER	Moreno			Moreno			?		Not reached

* Reproduced from Church, Solari, and others (1950).
** Reproduced from Corwin (1953b).

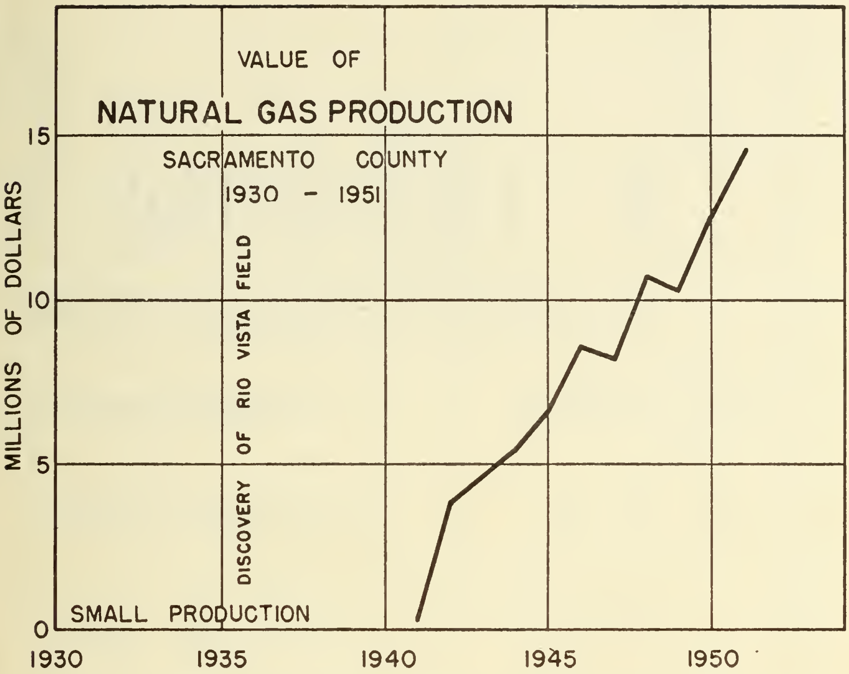

FIGURE 3. Value of natural gas produced in Sacramento County, 1930 to 1951.

County. This value nearly equaled the 1951 output of Los Angeles County, the leading natural gas producing county in the State. The Rio Vista gas field yielded by far the largest amount of natural gas production in Sacramento County. The Isleton gas field, although a separate structure from the Rio Vista field, is adjacent to and usually included as part of the Rio Vista field. Minor amounts of natural gas are also produced from the Thornton River Island and Freeport gas fields.

The first discovery of natural gas in Sacramento County was apparently about 1870 on the old Haggin Ranch (Irelan, 1887, p. 185) (Ireland, 1890, p. 505). At this date, inflammable gas arose from a 2250-foot well, which was originally drilled in search of water.

It was not until the winter of 1889-1890 that a sustained effort was made to discover natural gas in this county. At that time, the Sacramento Natural Gas and Water Company was organized to search for natural gas and water. By 1894 this company had discovered gas in the southwestern part of the Sacramento city limits. It is roughly estimated that the flow of gas from one of the company's wells exceeded 2,000 cubic feet in 24 hours (Crawford, 1894, p. 350). In 1896 the company had bored two wells which were 7 inches and 14 inches in diameter, 876 feet and 965 feet deep, respectively. From these wells flowed a large quantity of natural gas and water. Neither the gas nor the water was utilized at that time (Crawford, 1896, p. 567).

By 1916, the Sacramento Natural Gas and Water Company, which had changed its name to the Sacramento Natural Gas Company, owned eight producing gas wells in the city of Sacramento on the east side of

Table 2. Holes drilled for natural gas in Sacramento County, to January 1, 1953.

Map No.	T.	R.	Sec.	Company and well	Date started	Year completed or abandoned	Depth	Geology
33	10N	4E	17	Richfield Oil Corp., Natomas No. 1	3-43	4-43	5020	Cretaceous
34	10N	4E	28	Richfield Oil Corp., Natomas No. 2	5-43	5-43	3746	Cretaceous
35	9N	6E	8	Central Petroleum Co., No. 1	----	1925	2868	
	9N	6E	--	Central Petroleum Co.	----	1930	----	
36	9N	6E	9	Vinetz Oil Company, Donnie No. 1	10-48	11-48	2600	
37	8N	4E	11	Pacific Gas and Electric Co., No. 2	----	1932	1790	
38	8N	4E	11	Pacific Gas and Electric Co., No. 6	----	1930	1488	
39	8N	4E	11	Sacramento Natural Gas Co., No. 1	----	----	1300–1400	Gas Producer
40	8N	4E	11	Sacramento Natural Gas Co., No. 2	----	----	1800	Gas producer
41	8N	4E	11	Sacramento Natural Gas Co., No. 3	----	----	2005	Gas producer
42	8N	4E	11	Sacramento Natural Gas Co., No. 4	----	----	1600–1700	Gas producer
43	8N	4E	11	Sacramento Natural Gas Co., No. 5	----	----	1600–1700	Gas producer
44	8N	4E	11	Sacramento Natural Gas Co., No. 6	----	----	1560	Gas producer
45	8N	4E	11	Sacramento Natural Gas Co., No. 7	----	----	1680	Gas producer
46	8N	4E	11	Sacramento Natural Gas Co., No. 8	----	----	2016	Gas producer
47	8N	4E	11	Sacramento Natural Gas Co., No. 9	----	----	2212	Sh., gas producer
48	8N	4E	23	Jergins Oil Company, Sacramento No. 1	9-45	10-45	7460	Cretaceous
49	8N	4E	35	Portable Drilling Equipment and Supply Company—Richardson No. 1	4-41	8-41	119	
50	7N	4E	24	Standard Oil Co. of California, Correa No. 1	9-52	10-52	7490	Cretaceous
51	7N	5E	18	Standard Oil Co. of California, Sims Comm. No. 2	1952	1953	9419	Basement
52	7N	5E	29	Standard Oil Co. of California, Shapard No. 1	10-52	11-52	6755	Cretaceous
53	7N	6E	8	Independent Exploration Company Unit Plan No. 1 (Feldman, D. D.)	1-43	2-43	4518	Cretaceous
54	7N	6E	9	Shell Oil Co., Inc., Elk Grove Comm. No. 3-1	12-44	12-44	1678	Eocene
55	7N	6E	17	Shell Oil Co., Inc., Elk Grove Comm. No. 9-1	11-44	12-44	2778	Eocene
56	7N	6E	19	Independent Exploration Company "Unit Plan" 1	11-40	1941	4808	Basement
57	7N	8E	28	Sacramento Petroleum Company Meiss No. 1	10-29	1931	1214	
58	7N	8E	32	Alexander, H. L. and Homan, G. J., Gill No. 2	9-52	9-52	1422	
59	6N	7E	3	Alexander, H. L. and Homan, G. J., C. W. Bottimore 1	9-52	9-52	2734	
60	6N	7E	10	Colusa Oil and Gas Company, Harbison No. 1	11-41	----	800	
61	6N	7E	13	Alexander, H. L. and Homan, G. J., Gill No. 1	9-52	10-52	2500	Top of Basement 2475 ±

62	6N	7E	25	Associated Dev. Co.,—Mitchell No. 1	----	pre-1925	2000	
63	6N	7E	25	Associated Dev. Co.,—Mitchell No. 2	----	1926	2963	
64	6N	7E	25	Great American Petroleum Company, Rubens No. 1	9-34	1937	3045	Cretaceous
65	6N	7E	36	Laguna Oil Company, No. 1	1918	1919	1357	
66	5N	4E	6	Dunlap, D. D. and Dorothy, Dunlap Natural Gas, Graham Comm. No. 1	8-51	8-51	4554	Top Domengine 3868′ Capay shale 4150′ Capay grit 4440′ Midland sand 4464′
67	5N	4E	15	The Texas Company, Vorden No. 1	6-51	7-51	4775	Top Capay sand 4226′
68	5N	4E	35	The Texas Company, Walnut Grove Unit No. 1	3-45	4-45	4482	Cretaceous
69	5N	5E	6	D. D. Feldman Oil and Gas Co., Natl. Gas Corp—Kuhn No. 1	10-52	11-52	7501	
70	5N	5E	*25	Amerada Petroleum Company—Goodfellow No. 1	10-43	10-43	3772	
71	5N	5E	30	Jergins Oil Company, McCormack No. 1	5-43	7-43	5704	Cretaceous?
72	5N	5E	*36	Amerada Petroleum Corp., Capital Co. No. 1	4-43	7-43	8367	
73	5N	5E	36	Amerada Petroleum Corp., Gwerder No. 1	10-43	1943	3799	Eocene
74	4N	3E	21	Bishop Oil Company, Willmor No. 1	6-40	9-40	4142	
75	4N	4E	7	Standard Oil Co. of California, Lopes 1	1952			
76	4N	4E	11	The Texas Company, J. S. Brown (NCT-1) No. 1	5-51	8-51	4100	
77	4N	4E	11	The Texas Company, J. S. Brown (NCT-1) No. 1	7-51	8-51	4100	Top Domengine 3303′ Main Sand 3358′ Capay Shale 3690′ Base Capay Shale 3973′

the Sacramento River. The wells ranged from 1380 to 2935 feet in depth. These eight wells produced approximately 250,000 cubic feet of gas per day which was consumed in Sacramento (Waring, 1919, p. 404). By 1925, the company name had been changed again to the Sacramento Gas Company. In this year, eight wells which ranged in depth from 1,700 to 3,000 feet, were producing about 300,000 cubic feet of gas daily. The gas issuing from the wells was dry marsh gas, averaging 84% methane, the balance being nearly all nitrogen (Logan, 1925, p. 11).

In 1936, the Rio Vista gas field was discovered in Solano County but later development spread southward in Sacramento and Contra Costa counties. During August, 1943, the Thornton gas field was discovered. In May of 1950, another gas field was discovered in Sacramento County, the River Island field, and in May, 1952, the Freeport field was discovered.

Intense searching for new gas fields is now underway, not only in Sacramento County, but in all of northern California. Structural or stratigraphic traps are necessary for the accumulation of commercial quantities of natural gas. These traps are generally buried far beneath the alluvium of the valley floor and may present no surface evidence of their existence. They are likely to be found only by geophysical prospecting on an extensive scale, followed by the drilling of exploratory wells in the most favorable localities. The record of unproductive exploratory or wildcat wells thus far drilled in Sacramento County is presented in table 2.

Freeport Gas Field. The Freeport gas field was discovered in May, 1952, by Standard Oil Company of California's Sims Comm. No. 1, which is located in NE ¼ sec. 19, T. 7 N., R. 5 E., M.D.M. This discovery well flowed at a test rate of 3,717,000 cubic feet per day for several hours through a ¼-inch orifice. The total depth of the well is 7,000 feet and gas production comes from Upper Cretaceous sands.

Other wells were drilled in the immediate area of the discovery well in anticipation of extending the producing limits of the field, but of the six holes completed to November 18, 1953, all have been dry holes. These dry holes are as follows:

(a) Standard Oil of California:
  Correa, (24, 7N, 4E), 7490 T.D., bottomed in Cretaceous
  Shappard, (29, 7N, 5E), 6755 T.D., bottomed in Cretaceous
  Sims Comm. No. 2, (18, 7N, 5E), 9419 T.D., bottomed in Basement
  Dwyer (17, 7N, 4E), 8202 T.D., bottomed in Upper Cretaceous
(b) E. A. Bender
  Kramer No. 1 (26, 7N, 5E), 6452 T.D., bottomed in Basement
(c) Richard S. Rheem Operator
  Kirtlan Comm. No. 1 (22, 7N, 4E), 7482 T.D., bottomed in Cretaceous

Isleton Gas Field (Isleton Area, Rio Vista Gas Field). Although the Isleton gas field is either included as an extension of part of the Rio Vista gas field (Clark and others, 1951) (Bush, 1953) or as the Rio Vista gas field, Isleton area (Corwin, 1953a), the geologic structure of the field is separate from that of the Rio Vista field (W. Cunningham, personal communication, 1953). As a matter of precedent, the Isleton gas field will be included as part of the Rio Vista field in this report, although a few general statements regarding this field are warranted.

The field was discovered with the completion of D. D. Feldman (now Brazos Oil & Gas Company, operator) well No. "Gardiner" 1 in sec. 25,

T. 4 N., R. 3 E., M.D.M., on May 18, 1948. This discovery well was drilled to a total depth of 4,645 feet and a 5½-inch casing was cemented at that depth. Of the 11 producing wells now located in the field (October, 1953), 10 were drilled by the Brazos Oil & Gas Company and one by M. E. and Frank Silva Company.

The stratigraphy of the field is similar to that of the adjoining Rio Vista field. The structure of the field is a faulted anticline whose major axis trends northwest. The Isleton fault (Corwin, 1953a, p. 14) strikes northwest and is about 1400 feet northeast of the anticlinal axis. Closure against the Isleton fault has been the control for the accumulation of dry gas. The two gas-producing zones, which are Eocene in age, are the Capay and Midland units (Corwin, 1953a, p. 14).

The first deliveries of gas from the Isleton area began in April, 1949, and by July 1, 1953, a total of 12,315,946 Mcf. of gas had been withdrawn from the two productive zones, leaving a reserve as of July 1, 1953, of 14,786,304 Mcf. (Corwin, 1953, p. 16).

Rio Vista Gas Field. The Rio Vista gas field (Soper, 1943, pp. 591-594) (Frame, 1944, pp. 5-14), which is the largest gas producing field in California, is located on both sides of the Sacramento River in Solano and Sacramento counties with a small portion of the field extending south of the San Joaquin River into Contra Costa County. Since the discovery and early development of this field in Solano County, later development has spread southeastward into Sacramento County, and more recently into Contra Costa County.

The field lies principally in Sacramento County, and since 1941, this county has been the leading producer of natural gas from the Rio Vista gas field. The proved extent of the Rio Vista gas field as of December 31, 1951, was 25,580 acres (Bush, 1952, p. 32). The distance between northernmost and southernmost wells is 8½ miles and the distance between the westernmost and easternmost wells is 7½ miles. During 1951, 67,722,037 Mcf of gas were withdrawn and the gas reserves as of January 1, 1952 were estimated to be 1,623,445,933 Mcf (Bush, 1951, p. 27).

The field was discovered on June 18, 1936, when the Amerada Petroleum Corporation completed its "Emigh No. 1" well in section 26, T. 4 N., R. 2 E., M.D.M. in Solano County. This discovery well flowed at the rate of 8750 Mcf per day through a one-half inch tubing bean. The well was 4485 feet deep and an 11¾ inch casing was cemented at 4278 feet with a 6⅝-inch liner landed on bottom.

By October 31, 1953, 186 wells had been drilled in the Rio Vista gas field, 169 of which were completed gas wells and 17 of which were abandoned as non-productive. Eighty-nine of the 169 gas producing wells are located in Sacramento County. Three additional wells were in the process of drilling in the field at that date. Of the 169 productive gas wells, 74 were drilled by the Amerada Petroleum Corporation; 51 by the Standard Oil Company of California; 18 by the Texas Company; 11 by the Brazos Oil and Gas Company; 6 by the Natural Gas Corporation of California; 5 by the Superior Oil Company; 2 by the Monterey Oil Company; and 2 by the Tracy Drilling Company.

The general structure of the Rio Vista gas field is a broad, flat anticlinal dome which has been faulted. The dome is somewhat elongated, with the axial line trending northwest. Dips are very flat throughout the field with few local exceptions. The extreme range in the elevation of the top of the gas zone in all productive wells west of the Sacramento River is 430 feet across a distance from north to south of about 3.1 miles, clearly showing the flat nature of that portion of the structure (Soper, 1943, pp. 593-594).

The major fault in this field is known as the Midland fault. Drill hole data indicate that the Midland fault is actually a fault zone trending east of north with a maximum throw of about 500 feet down on the west side.

There are two significant differences in stratigraphy on the two sides of the Midland fault zone; 1) on the east side the Capay shale is 500-700 feet thinner; 2) and on the east side the Eocene section below the Capay is an almost continuous sand body (Midland sand). [See plate 3 for the geologic section through the Rio Vista gas field.]

The middle Eocene Domengine formation contains gas in the Emigh zone, which occurs on both sides of the Midland fault. It is the earliest and most extensively exploited zone in the Rio Vista field. The average porosity of the gas zone may be 30 to 34 percent and the average permeability about 200 milidarcys. The original reservoir pressure in the field was 1725 psi, except in the Texas Company's well ''Midland Fee No. 1'' where the reservoir pressure was 1590 psi (Soper, 1943, p. 594). A typical analysis of the gas produced from the Emigh zone is as follows (Frame, 1944, p. 13):

Methane (CH_4)	94.79%
Ethane (C_2H_6)	2.82
Propane (C_3H_8)	0.72
Isobutane (C_2H_{10})	0.17
Nitrogen (N_2)	1.50

The second gas zone, which is encountered on both sides of the Midland fault, is called the Margaret Hamilton sand west of the fault and is part of the Midland sand east of the fault. This sand is part of the Meganos formation (lower Eocene to upper Paleocene) and lies directly under the Capay shale. The zone is approximately 1350 feet below the top of the Emigh zone west of the Midland fault and only 650 feet below the top of the Emigh zone east of the fault (Frame 1944, p. 11). John F. Dodge reported the reservoir pressure to be 2375 pounds per square inch (Frame, 1944, p. 11).

On the west side of the Midland fault zone, the third gas-producing zone is the Anderson sand of the lower Eocene Meganos formation. This zone is approximately 250 feet below the top of the Margaret Hamilton sand (Frame, 1944, p. 11). The gas-producing zone east of the Midland fault is part of the Midland sand.

River Island Gas Field. The River Island gas field was discovered in June 1950 with the completion of the Brazos River Islands Land Company No. 1 in sec. 29, T. 4 N., R. 4 E., M.D.M. The well was drilled to a total depth of 5,158 feet and a 5½-inch casing was cemented at 4,951 feet.

The structure of the field is a faulted anticlinal nose which slopes gently to the southwest (W. Cunningham, personal communication, 1953). Faulting has resulted in the closure of the formations and controls the accumulation of natural dry gas. The three main faults, all of which strike northwestward and affect gas production, are the West River Island, East River Island, and Brandt faults (Corwin, 1953b, pl. 2). Producing zones are in the Nortonville, upper and

Table 3. Productive Gas Wells in the Thornton Gas Field, Sacramento County, to January 1, 1953

Well	Company	Location			Date completed	Total depth	Remarks
		Sec.	T.	R.			
Amerada Capitol No. 1	Amerada	36	5N	5E	July 1943	8367	Top Meganos 3355
Amerada Capitol Community No. 2	Amerada	27	5N	5E	July 1944	3333	Top Meganos 3279
Amerada Goodfellow No. 1	Amerada	25	5N	5E	Oct. 1943	3772	Top Meganos 3350
Amerada Goodfellow Capitol No. 1	Amerada	26	5N	5E	Aug. 1949	3350	Top Meganos 3309
Amerada Nicolaus No. 1	Amerada	26	5N	5E	Sept. 1946	3400	Top Meganos 3355
Amerada Thornton Unit No. 1	Amerada	28	5N	5E	Dec. 1945	3360	Top Meganos 3285
Amerada Thornton Unit No. 2	Amerada	28	5N	5E	Aug. 1946	3400	Top Meganos 3320
Amerada Weinzheimer No. 1	Amerada	34	5N	5E	Nov. 1945	3376	Top Meganos 3342
*Amerada Housken Community No. 1	Amerada	28	5N	5E	Sept. 1943	6003	Top Meganos 3285
*Amerada McGillivray Community No. 1	Amerada	29	5N	5E	Mar. 1944	3500	Top Meganos 3335
*Dinelli No. 1	Allison & Prestridge	29	5N	5E	Jan. 1952	4070	Nortonville 2880 Capay 3206

* These wells located in San Joaquin County.

lower parts of the Domengine formation, and Midland sand, all of Eocene age (see plate 2).

At the present time (October 1953) there are 24 producing wells in this field. Of the 24 producing wells, 17 were drilled by the Brazos Oil & Gas Company, four by Standard Oil Company of California, two by the Texas Company, and one by Henry Hottinger and Basil Zavico.

The calorific value of the gas ranges from 969 to 1010 B.t.u.'s. The first deliveries of gas from the River Island gas field began in October 1950, and a total of 11,802,545 Mcf. of gas had been produced to July 1, 1953. The gas reserves as of July 1, 1953, was 15,130,359 Mcf. (Corwin 1953b, p. 20).

Thornton Gas Field. Although the Thornton gas field was discovered in San Joaquin County in August, 1943, the major portion of the field at the present time lies within Sacramento County. Amerada Petroleum Corporation drilled the discovery well, Amerada Housken Comm. No. 1, in sec. 28, T 5 N., R. 5 E., M.D.M.

During 1951, ten wells withdrew 999,744 Mcf. of gas. The estimated gas reserves of the field as of January 1, 1952 were 11,261,727 Mcf. (Bush, 1951, p. 26). In January 1952, the eleventh successful well was completed. See table 3 for detailed information on the eleven producing wells, plate 3 for a geologic section through the field, and the correlation chart. The structure of the field is an anticlinal dome trending east. The gas-producing zone is the lower Eocene ''Capay sand or Capital sand'' (Church et al., 1950, correlation chart) which lies directly beneath the Capay shale.

Peat

Peat valued at $42,016 was produced in California during 1951. Although Sacramento County does not have a recorded peat production, the thickest deposits in this state are believed to underlie the central part of the Sacramento delta. The extent of this area is approximately 432 square miles or 276,460 acres with peat to a thickness of from 6 to 80 feet (Laizure, 1923, p. 107). The southwestern tip of Sacramento County is located in this area.

Peat is an accumulation of vegetal matter that has undergone decomposition and disintegration. It forms in lakes, swamps, and river deltas from mosses, tules and grasses; a deficiency of oxygen prevents complete decay, and the carbonaceous matter is preserved (Braun, 1950, p. 83).

One reason a peat industry has not developed in Sacramento County is probably because this land is among the most valuable agricultural land in California.

Platinum Group Metals

Platinum group metals have been produced almost continuously in Sacramento County since 1905. These metals occur in the gravel deposits along the ancient and modern course of the American River and its tributaries and along the Cosumnes River, and have been recovered entirely as a by-product of the gold dredging operations (Logan, 1925, p. 22). In nearly all of the placer deposits of California the proportion of platinum metals to gold is small. This proportion, as indicated by

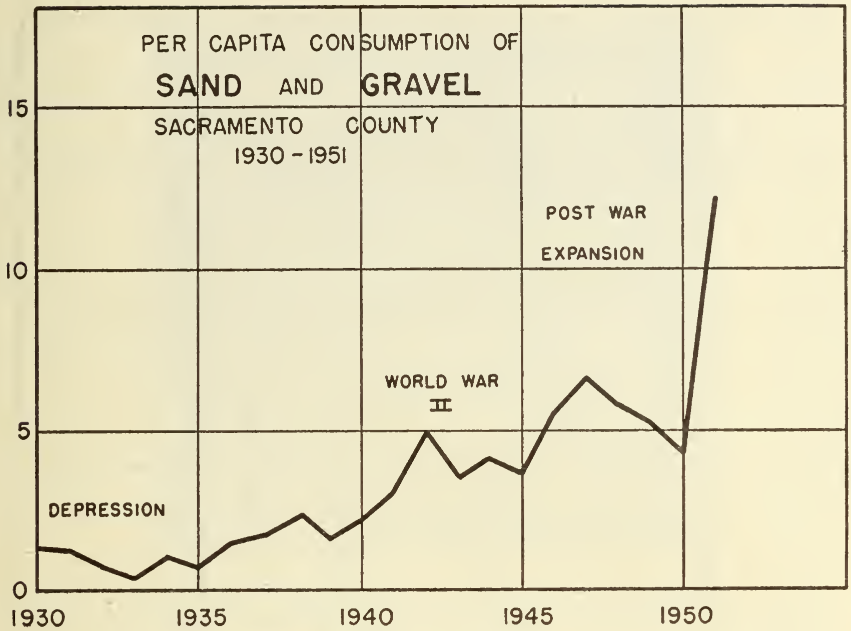

FIGURE 4. Per capita consumption of sand and gravel in Sacramento County, 1930 to 1951.

dredge recovery, has ranged from one ounce to one-third of an ounce of platinum metal for every 50 ounces of gold (Logan, 1950, p. 341).

Platinum is one of a group of six related precious metals: ruthenium, rhodium, palladium, osmium, iridium, and platinum. So-called crude platinum is generally an alloy of two or more metals of this group.

The platinum group metals that occur in this county were weathered from an ultrabasic rock, peridotite, or from serpentine derived from peridotite. Belts of serpentine trending west of north crop out in counties east of Sacramento County.

The average of five assays made upon lots of from thirty to eighty ounces each showed 43.49% platinum and three of these showed 22.57%, 23.13% and 25.17% iridium. Osmium was not accounted for, but probably averaged about 30% (Logan, 1925, p. 22).

Sand and Gravel

Sacramento County yielded 3,577,191 short tons of sand and gravel in 1951. This figure represents slightly more than 7 percent of the state's total for that year. The county's output of sand and gravel had a value of $4,012,848, which was surpassed only by the value of natural gas, during 1951.

From 1880 to 1951, 21,986,658 short tons of sand and gravel valued at $13,314,855 were produced in Sacramento County. Of this grand total, slightly more than half of the production has been since 1943. This is a direct result of the increased demands on the industry during World War II and the post-war industrial and building activity. Figure 4 is a graph showing the per capita consumption of sand and gravel in Sacramento County from 1930 to 1951.

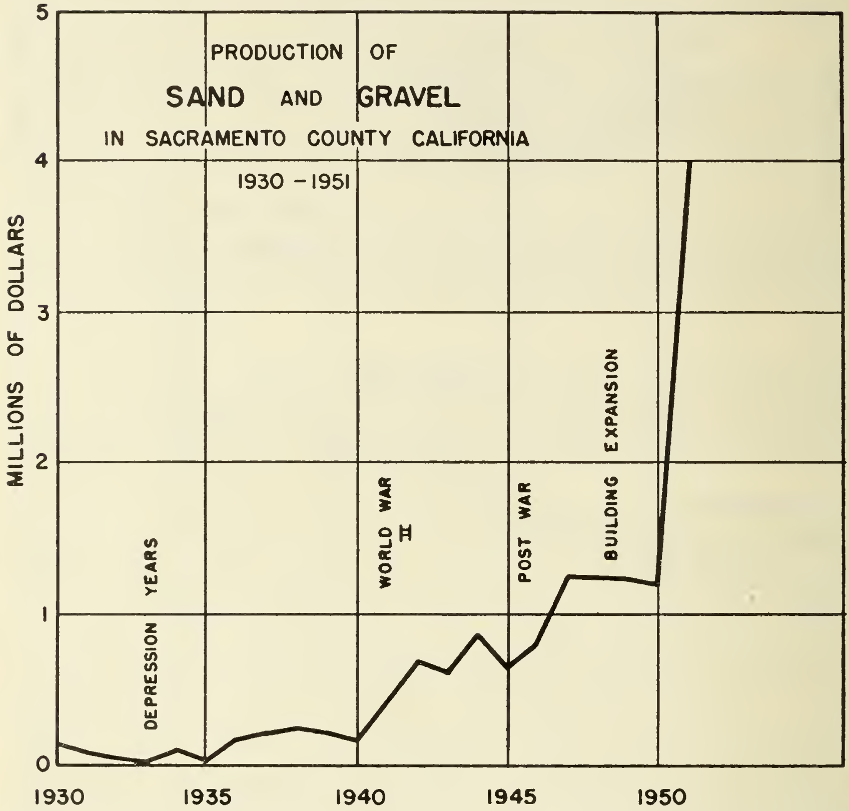

FIGURE 5. Value of sand and gravel produced in Sacramento County, 1930 to 1951.

All of the active sand and gravel operations in Sacramento County are located in and adjacent to the American River between Folsom and Sacramento. The first sand, gravel, and crushed rock produced in the county was by the Natomas Consolidated of California (Natomas Company). This plant was built in 1909 to convert dredge tailings to a commercial product (Waring, 1916, p. 413). By 1925, the number of sand, gravel, and crushed rock operations had increased to six (Logan, 1925, pp. 16-21). At the present time, there are 21 properties which are either active or intermittently active.

Most of the county's present output of sand and gravel is used as aggregate in construction and road building. Appreciable quantities are used as crushed rock-macadam, while minor amounts of ballast, rubble, and riprap are also produced.

Aggregates from Sacramento County are being utilized in the concrete sections of Folsom and Nimbus dams, in the earth-filled dams or dikes in conjunction with Folsom Dam, private dwellings, and Federal, State, and private buildings and roads. Appreciable quantities of sand and gravel are used in road and building construction at the U. S. Army Signal Depot, and at McClellan and Mather U. S. Air Force fields.

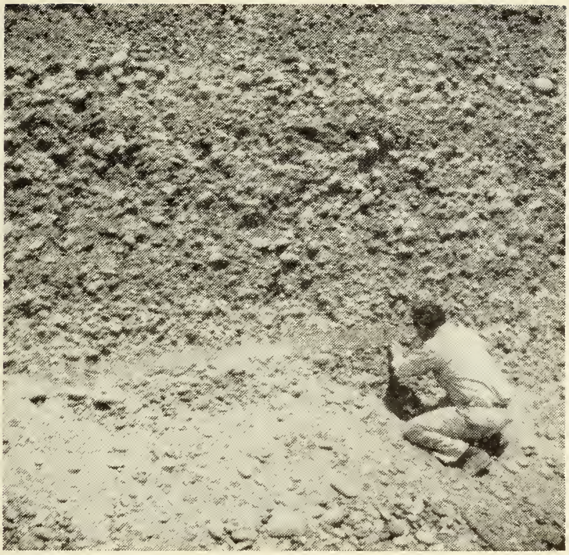

FIGURE 6. Typical section of unconsolidated fluviatile Victor formation. The Victor formation is a commercial source of sand and gravel in Sacramento County. *Photo by Thomas E. Gay Jr.*

In addition to producing sand and gravel, many of the county's operators produce hot-mix in separate hot-mix plants, concrete in separate batch plants, and road rock in separate road rock plants. Some by-product gold is recovered from several of the sand and gravel plants.

Geology and Petrology of Deposits

The source material for the sand, gravel, and crushed rock industry generally comes from three distinct types of deposits: old Pleistocene floodplain terrace material (Victor formation) generally buried from 2 to 20 feet by soil; Recent low floodplain terrace deposits mantled by a shallow fine alluvial overburden; and recently replenished river-bar deposits in stream beds. These deposits are similar in that the source of the aggregate is the Sierra Nevada, but there are minor differences in the degree of weathering and proportions of certain rock types, particularly vein quartz. The particles consist of massive to sub-schistose metamorphic and plutonic igneous rocks. These rocks are well-rounded, very tough and are free from flat materials. There is a notable deficiency of objectionable material such as soft sandstones, slaty and schistose metamorphic rocks.

The coarse sand is composed chiefly of rock fragments similar in composition to the pebbles and cobbles found in the gravel. The fine sand is composed of quartz and feldspar with minor amounts of hornblende and other heavy minerals. Compared to other Sierran river gravels, the mica content in these sands is notably low.

During Pleistocene time, the Victor formation was deposited when the ancestral American River channel was shifting across what is now

Table 4. Petrographic Analyses of Lower American River Concrete Aggregates, Sacramento County, California.

Lithological classification of 1½- to ¾-inch gravel based on counts of 200 to 400 pebbles for each sample		Victor formation	Recent streambed		Recent terraces
Andesite	Composed partly of crystals and partly of glass, porphyritic, fine grained, hornblende-pyroxene andesite derived from Tertiary agglomerates which are widespread in the drainage area. Characteristically very well-rounded. Comparatively soft and less resistant to weathering than the associated rocks; deeply weathered unsound pebbles are present	4	4	7	9
Vein Quartz	Pure milky white, coarsely crystalline, hard but fairly brittle, rounded. Typical of Eocene auriferous gravels. Half or more of the vein quartz fragments in the riverbed are from old hydraulic mine debris.	4	9	13	1
Metamorphics—non-schistose quartzitic meta-sediments	Mostly tough, massive impure quartzites; some gneissoid rocks and dense fine-grained metamorphosed chert. The latter are associated with vein quartz in the Eocene auriferous gravels.	34		26	28
basic meta-igneous	Very sound, mildly to moderately metamorphosed, massive, fine and medium-grained basic pyroclastics. Includes some andessitic meta-volcanics and rare serpentine.	36	76*	37	43
amphibolite	Tough, sub-schistose to massive, fine to medium grained texture.	7		5	3
hornfels	Very sound, dense, dark, very fine to fine grained texture. Often show relic bedding structure. Mostly metamorphosed argillites.	4		8	6
Plutonic igneous granitic	Fine to medium grained granitic rocks mostly aplitic and gneissoid types. Typical Sierran granodiorite scarce. Occasionally deeply weathered and infirm, but generally sound.	7	4	2	5
dioritic-gabbroic	Fine to medium grained basic rocks; hornblendic. Excellent physical quality.	4	7	2	5

*Undifferentiated

Sacramento County. This gradual shifting of the channel, coupled with seasonal floods, resulted in widespread deposition of sand and gravel. As is characteristic with floodplain deposits laid down by frequently shifting streams, the Victor formation is characteristically heterogeneous and contains lenticular members. The rocks are locally weathered but not to a degree sufficient to render them unsuitable for concrete aggregate. West of the east county line, the particle size of the rocks in the Victor formation becomes progressively smaller and there is a noticeable lack of cobbles in the western portion of this formation.

A second group of sand and gravel deposits utilized in this county and similar in mode of deposition and lithologic classification to the Victor formation are the terrace deposits of Recent age. These deposits, which have a shallow overburden of silt, are located adjacent to the present river system.

The third type of deposit is the Recent alluvium in the present stream bed. Additions to these deposits are continually taking place by river and stream action. These gravels are characterized by notably higher vein-quartz content.

Specifications

Production of aggregate suitable for use in concrete is the main problem of the sand, gravel, and crushed-rock industry. Aggregates should be essentially inert filler in concrete, although they make up approximately three-fourths of the volume of concrete. Aggregate must conform to certain chemical and physical requirements so that harmful reactions will not take place in the concrete and high quality and strength are attained in the concrete.

Generally, aggregates should consist of hard, durable, clean particles free from readily reactive minerals or coatings of clay or other fine material which would adversely affect the bonding of cement. It is obvious that weak, friable, and laminated particles such as shale should be avoided. Visual inspection of aggregates will tend to disclose whether they are suitable for concrete aggregate, but where a doubt exists, the aggregate should be tested. This is particularly true when the aggregate is suspected to contain reactive materials. Damage to concrete such as pattern cracking, popouts, and expansion may be the result of aggregate-alkali reaction. Certain minerals in certain aggregate particles combine chemically with soluble alkali-hydroxide (and in some cases free lime) derived from the cement to form gels. The damage to concrete has been attributed to osmotic pressure or to simple swelling of the gels as they hydrate (Merriam, R., 1953, pp. 4-5).

A good picture of the proportions and types of rocks comprising the gravels can be obtained from table 4 which has been abstracted from a more detailed compilation of petrographic data on these deposits (Klein 1949, unpublished report).

Merriam (1953, p. 6) states that the following rocks and minerals are considered to be reactive with high-alkali cements:

Reactive minerals	Chemical composition	Physical character
opal	$SiO_2.nH_2O$	amorphous
chalcedony	SiO_2	cryptocrystalline fibrous
tridymite	SiO_2	crystalline

Reactive rocks	Reactive component
Siliceous rocks:	
opaline chert	opal
chalcedonic chert	chalcedony
siliceous limestone	chalcedony and/or opal
Volcanic rocks:	
rhyolites and rhyolite tuff dacite and dacite tuff andesites and andesite tuff	volcanic glass, devitrified glass and tridymite
Metamorphic rocks:	
phyllites	hydromica
Miscellaneous rocks:	
any rocks containing veinlets, inclusions or grains of the reactive rocks or minerals listed above.	

In the three distinct types of sand and gravel deposits now being worked in the county, andesite is the only chemically deletrious material present in significant quantity, except for a few percent of possibly slightly reactive chert and phyllite. Occasionally fragments of opaline petrified wood are too rare to be important. Klein (1949, unpublished report) states that the total content of reactive materials is too low to cause disruptive expansion even if used with high-alkali cement. Mortar-bar expansion tests by the California Division of Highways on sands from the Victor formation show expansion of less than 0.1 percent in one year with high-alkali cement. Deterioration due to alkali-reactivity of these very widely-used aggregates has not been reported.

Two general ways in which aggregates are tested to determine their suitability as concrete aggregate are by petrographic analyses and by certain tests as prescribed by the American Society for Testing Materials, standard specifications for concrete aggregate, ASTM Designation C33.

Below are listed the test results of aggregate from the three distinct types of sand and gravel deposits now being worked in Sacramento County. These tests were performed by the U. S. Army Corps of Engineers at their South Pacific Division Laboratory, Sausalito, California, during the period from January to June, 1950. This work was done in connection with their studies on the concrete aggregate investigation for the Sacramento River Deep Water Channel. Although the U. S. Army Corps of Engineers use magneisum sulfate for the soundness test while the A. S. T. M. Standard prescribes sodium sulfate, the tests accomplish a similar purpose.

	Deposits					
Test	*C*	*A*	*E*	*D*	*F*	*B*
Los Angeles abrasion Test (500 rev.)	16.2	17.9	17.1	15.7	16.5	15.0
Decantation (% passing #200 sieve)	2.9	1.0	0.7	1.6	2.4	1.7
Magnesium sulfate soundness (% loss)						
½"-1"	0.6	3.3	2.0	0.6	2.6	1.0
#4 - ½"	3.2	6.0	4.0	3.2	4.7	1.5
sand	8.5	12.4	9.1	10.3	14.9	11.1
Bulk specific gravity						
¾"- 1½"	2.85	2.76	2.79	2.78	2.77	2.77
#4 - ¾"	2.77	2.74	2.78	2.76	2.71	2.79
sand	2.65	2.64	2.70	2.65	2.58	2.66
Absorption (%)						
¾"- 1½"	0.2	0.9	0.6	0.8	0.4	0.4
#4 - ¾"	0.8	0.9	1.2	0.8	1.0	0.8
sand	1.7	2.1	1.9	1.9	3.2	2.0
Mortar strength	1.12	0.93	1.10	1.01	0.81	0.84
Colorimetric test	clear	clear	clear	clear	clear	clear
Freeze-thaw test (D.F.E. @ 300 cycles)						
Set 1	80	74	73	60	75	68
Set 2	91	91	63	69	92	74
Set 3	80	86	72	71	84	87

The Los Angeles abrasion or Rattler test is used to determine the percent of loss from abrasion after a screened sample of aggregate and cast iron shot have been revolved in a small cylinder. After revolving the screened aggregate and cast iron shot a certain number of revolutions, usually 500, the aggregate is rescreened to determine the amount of undersize which has been produced. This undersize represents the percent loss of the sample. An aggregate loss that is below 30 percent is generally considered to be within favorable limits.

For testing the soundness of aggregate, a screened sample is suspended in a magnesium sulfate solution for a period of time and then withdrawn from the solution and allowed to dry. The standard procedure requires a 5-cycle soaking and drying. Upon drying, the magnesium sulfate crystallizes and the force of crystallization loosens and flakes off material from the aggregate particles. Therefore, the results of this test represent the percent of aggregate loss from the crystallization of magnesium sulfate in the concrete.

Bulk specific gravity, the overall specific gravity of the sample tested, should be greater than 2.55.

The absorption test is used to determine the amount of moisture absorbed by the sample and is expressed in percent by weight. Mortar strength is the ratio of compression strength of a small concrete cylinder made with the aggregate in question as compared to one made with Ottawa sand.

In the colorimetric test, sodium hydroxide is added to the aggregate sample to determine the amount of organic material present. A lack of color indicates a lack of organic material.

Undeveloped Resources

There are fairly large undeveloped aggregate resources in Sacramento County. The Victor formation (Pleistocene) which generally contains very suitable concrete aggregate, underlies extensive areas in Sacramento County. Generally, the deposit in the vicinity of the presently active operations is around 35 to 45 feet thick under a soil overburden ranging from 2 to 20 feet in thickness. Generally speaking, the overburden masking the Victor formation increases from east to west. The amount of aggregate quarried from this formation in Sacramento County is negligible when considering that the entire formation represents a potential source of aggregate.

Operations

Production of sand, gravel, and crushed rock entails three main phases of operation: quarrying, classifying, and crushing. A generalized description of operations by different sand and gravel operators in Sacramento County follows.

Sand and gravel mining in Sacramento County is done entirely by open-pit methods. Sand destined principally for use by the mortar industry is mined by subaqueous methods.

Open pit excavation is accomplished mainly by dragline excavators, although power shovels and a few backhoes are also used. Bucket capacities on these different types of equipment range from ½ to 2½ cubic yards. Diesel and some diesel-electric units furnish the power for the excavation equipment. End- and bottom-dump trucks are used to haul raw material to the aggregate plant, which is generally located within a mile from the pit.

Subaqueous methods of mining sand are accomplished by so-called suction dredges which consist of a suction pump mounted on a floating barge. The three suction dredges that operate in this county are located on the American River. These suction dredges are able to excavate fines up to 25 feet below the water level. Suction pumps on these dredges range in size from 5 to 7 inches and are powered by electric motors whose rated capacity ranges from 75 to 350 horsepower.

Fines from the river bottom are sucked into a pipeline which feeds the classifying plant. At the Hard Materials Company's suction dredge, a pump pressure of from 40 to 45 psi is maintained. At this pressure, the suction pump is able to feed fines and water to the classifying plant through 2000 feet of 10-inch pipe at a velocity of about 13 feet per second.

Raw material is classified, washed, and crushed in many aggregate plants throughout the county. Some aggregate plants are divided into a "rock" or uncrushed rock unit and a crushed rock unit, but in every case, both units are integrated with each other. Pit-run material is generally deposited into a receiving storage bin at the aggregate plant. A grizzly rejects cobbles and boulders too large for the primary crusher. Inclined conveyor belts transport the material to the first plant screening tower. Revolving inclined trommels with one or more size perforations or single, double, or triple deck vibrating screens are used in this first classification process. One operator utilizes a scrubber to aid in washing the aggregate. The sand phase is generally separated from the pit-run material in the revolving trommel. The sand phase, which usually consists of minus $\frac{3}{16}$-inch particles, may run over gold riffles at plants where gold is recovered or may be fed directly into a fines classifier, such as a rake or screw classifier, or both. The sand is then customarily fed onto an inclined belt conveyor that transports the material to a yard stockpile. One operator in the county utilizes an inclined radial conveyor belt with a 290 degree arc to stockpile sand.

Undersize from the screen tower other than the sands either falls directly into size bins or is transported by belt conveyor to other screens or crushers. Primary crushing is generally by jaw crushers although one operator uses a primary gyratory crusher. Secondary crushing is done both by roll and cone crushers and one operator utilizes a rod mill. Tertiary crushing is done principally by cone crushers. Crusher settings, screen sizes and flow sheets are varied to accomodate the average size range of raw material to the desired final products.

The washed sand, gravel, and crushed rock are either stored in elevated bins, bunkers, or in yard stockpiles. Trucks and railroad cars are gravity loaded from the elevated bins for shipment to the market. In cases where the products are stored in yard stockpiles, front-end loaders or conveyor belt-feeders are usually used to load the material into trucks.

In general, American River aggregates are deficient in sand, and the sand contains excess amounts of the size fractions U. S. Standard Screen sizes Nos. 16 to 50. Here the sands are deficient in fines or material that will pass a No. 50 screen. Because of this natural deficiency of fines in the sands fraction of the aggregate, an operator may either haul these fines from other areas which may possibly be located outside the county, manufacture them by auxiliary crushers, or by saving them from the normal crushing operation of the aggregate plant.

To reduce the fines loss by sliming, some whirlcone separators and hydraulic sizers are used. By controlling the feed and pressure in a whirlcone separator, a saving and control of the particle size of the fines is effected, particularly those particle sizes below 100 mesh. A hydraulic sizer enables the operator to exercise rather precise control on the grain size within small limits. By utilizing a sizer, some fines may be saved and others wasted, depending upon the specifications that are to be met.

One problem that confronts a few operators who excavate sand and gravel from the American River channel is that of contamination. Contaminating materials consist of flood-borne brush and other debris deposited with the sand and gravel during the winter high-water season. Eddies form in the pools resulting from digging, and wood fragments become waterlogged and sink, thus contaminating the sand and gravel to such an extent that it would be extremely difficult to produce clean aggregate.

Many sand and gravel operators in this county maintain separate road rock plants. The plant flow-sheet of most of the road rock plants is so arranged that a product of minus 1½ inches is produced. This plant is usually separate from and not integrated with the main aggregate plant. Pit-run material is trucked from the pit and deposited into a receiving bin and conveyed to a dry 1½-inch screen. The undersize falls directly into an elevated storage bin while the oversize falls into a jaw crusher with a set of 1½ inches and then into the storage bin. This minus 1½-inch product, commonly called ''road rock,'' is then gravity loaded into trucks and hauled to the job-site.

Listed below are 21 active sand and gravel operations in Sacramento County.

American River Sand and Gravel Co.

Location: sec. 14, T. 8 N., R. 5 E., M.D.M., ¼ mile southwest of Perkins
Began operating: 1941
Markets: wholesale and retail
Status in 1953: active
Deposit: flood-plain deposit of the Victor formation; predominant aggregate size is minus 4 inches; 12 to 14 feet of clay-soil overburden
Quarrying equipment: power shovel
Size of pit: 3 to 4 acres and 40 feet deep
Distance to plant: about 1 mile
Crushing equipment: primary jaw, secondary roll (Portable Universal crusher)
Classification equipment: scrubber, vibrating screens, rake and screw classifier and inclined conveyor belts
Products: sand, gravel, and cobbles
Rated capacity: 125 to 150 tons per day
Employees: 8

The all-portable plant is on the edge of the 40-foot-deep pit and the classified products fall down troughs into yard stockpiles at the bottom of the pit.

Brighton Sand and Gravel Co.

Location: sec. 24, T. 8 N., R. 5 E., M.D.M., 1 mile southeast of Perkins
Began operating: 1937
Markets: 95% of products consumed on company contract jobs, 5% retail
Status in 1953: active
Deposit: flood-plain deposit of the Victor formation; predominant aggregate size is minus 4 inches; 2 to 12 feet of clay-soil overburden
Quarrying equipment: Dragline excavators and power shovels
Size of pit: 15 acres and 45 feet deep
Distance to plant: about 1 mile
Crushing equipment: primary jaw, secondary roll

Classification equipment: inclined trommel, vibrating screens, screw classifier, and inclined conveyor belts
Products: sand and gravel
Rated capacity: 300 tons per hour
Employees: 15

The plant also includes hot-mix plant and batch plant. Some gold is recovered from riffles.

Del Paso Rock Products Company

Location: secs. 1 and 12, T. 8 N., R. 5 E., M.D.M., 2 miles northeast of Perkins
Began operating: 1928
Markets: wholesale and retail
Status in 1953: active
Deposit: river channel and bar deposit, Recent alluvium, predominant aggregate size is minus 4 inches, no overburden
Quarrying equipment: dragline excavators
Size of pit: 2 miles in and along American River, and 3 to 14 feet deep
Distance to plant: about 1 mile
Crushing equipment: primary jaw, secondary and tertiary cones
Classification equipment: vibrating screens, rake classifier, inclined trommel, and inclined conveyor belts
Products: sand and gravel and road rock
Rated capacity: 100 tons per hour
Employees: 25

This plant also includes batch plant and road rock plant. Small bottom-dump rail cars, moved by winch-operated cables, are used to transfer gravel from the bunkers up an inclined ramp and trestleway about 500 feet long over the stockpiles containing the $\frac{3}{4}$-to $1\frac{1}{2}$-inch and $1\frac{1}{2}$-to 3-inch gravel. Gold recovered in riffles averages 1 cent per cubic yard.

Fair Oaks Gravel Company

Location: secs. 8 and 17, T. 9 N., R. 7 E., M.D.M., at Sailors Bar
Began operating: 1944
Markets: wholesale and retail
Status in 1953: active
Deposit: river bar (Recent) and terrace deposit of the Victor formation; predominant aggregate size is minus 5 inches; 1 to 3 feet of silty-soil overburden.
Quarrying equipment: power shovels
Size of pit: 20 acres, and 20 to 30 feet deep
Distance to plant: $\frac{3}{4}$ mile
Crushing equipment: primary jaw, secondary cone
Classification equipment: inclined trommel, vibrating screens, sand drag, bucket elevator, and inclined conveyor belts
Products: sand and gravel
Rated capacity: 60 tons per hour
Employees: 7

Gold which is recovered in riffles averages between 7 and 12 cents per cubic yard.

Haggin Gravel Company (J. R. Reeves)

Location: secs. 32, 33, T. 9 N., R. 6 E., and secs. 4 and 5, T. 8 N., R. 6 E., M.D.M., on north side of American River $1\frac{1}{2}$ miles west of Mills
Began operating: 1946
Markets: wholesale and retail
Status in 1953: active
Deposit: river terrace deposit of Recent alluvium; predominant aggregate size is minus 5 inches; 3 to 15 feet of silty-soil overburden
Quarrying equipment: dragline excavators
Size of pit: parts of 100 acres, and 35 feet deep
Distance to plant: about $1\frac{1}{4}$ miles
Crushing equipment: primary jaw, secondary and tertiary cones
Classification equipment: inclined trommel, rake classifier, vibrating screens, and inclined conveyor belts
Products: sand and gravel, road rock and ballast
Rated capacity: 1800 tons per day
Employees: 30

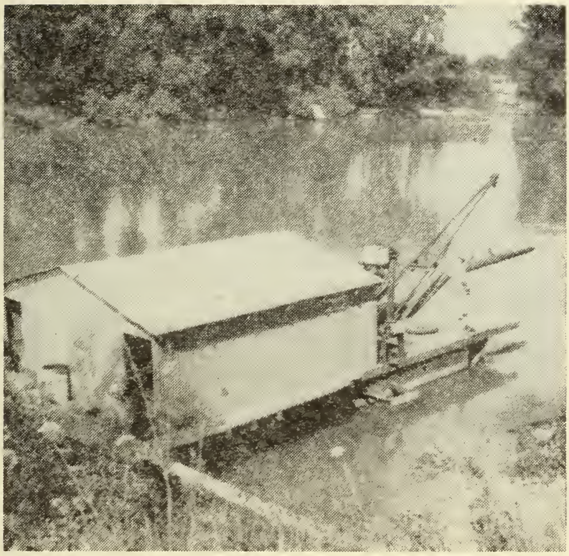

FIGURE 7. Hard Materials Company's suction dredge on the American River. The derrick on the barge (right side of photo) enables the operator to raise or lower the suction nozzle. *Photo by Thomas E. Gay Jr.*

Plant also includes road rock plant, batch and hot-mix plant. Some gold is recovered. Overburden is marketed as topsoil.

Hard Materials Company

Location: sec. 25, T. 9 N., R. 4 E., M.D.M., at North 12th Street and American River, Sacramento
Began operating: 1951
Markets: mostly wholesale, some retail
Status in 1953: active
Deposit: river channel deposit, Recent alluvium; predominant aggregate size is 30 to 60 mesh; no overburden
Quarrying equipment: suction dredge equipped with 5-inch suction dredge pump
Size of pit: 5 acres of American River channel, and 18 to 30 feet deep
Distance to plant: 2000 feet
Crushing equipment: none
Classification equipment: screen, rake classifiers, hydro-separator and inclined conveyor belts
Products: plaster and mortar sand, putty and mortar
Rated capacity: 400 cubic yards per day
Employees: 11

Fines are pumped from the bottom of the American River through 2000 feet of 10-inch pipe to the classifying plant. Plant equipment also includes a lime slacking plant.

Lentz Sand Pit

Location: sec. 35, T. 9 N., R. 4 E., M.D.M., near Jibboom Street Bridge, Sacramento
Began operating: 1950
Markets: most of product consumed on company contract jobs
Status in 1953: intermittently active
Deposit: river channel deposit, Recent alluvium; predominant aggregate size is minus $\frac{3}{16}$ inches; no overburden
Quarrying equipment: power shovel
Crushing equipment: none
Classification equipment: none

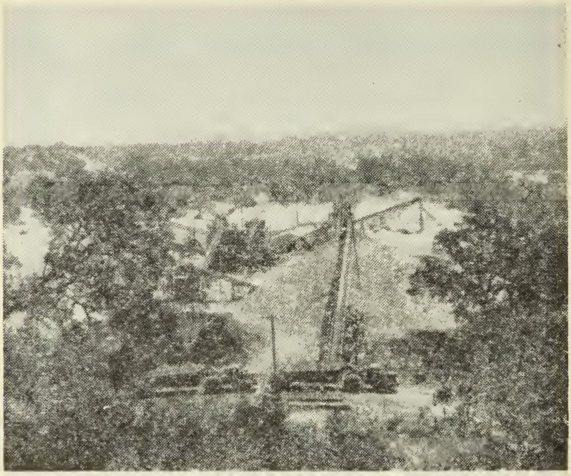

FIGURE 8. Merritt Savin Construction Company's aggregate plant near Folsom. All concrete aggregate produced at this plant is used in construction of the Folsom Dam. *Photo by Thomas E. Gay Jr.*

Products: fill sand

The company intermittently operates this sand pit as a source of fill material. The sand is dredged from the Sacramento River and deposited at this site by the U. S. Army Corps of Engineers.

Mayhew Pit

Location: sec. 10, T. 8 N., R. 6 E., just west of Mather Field
Began operating: 1941
Markets: product consumed on company contract jobs
Status in 1953: intermittently active
Deposit: flood plain deposit of the Victor formation; predominant aggregate size, minus 6 inches; 2 to 7 feet of clay-soil overburden
Size of pit: 5 acres; as much as 15 feet deep
Products: concrete aggregate and paving aggregate

This sand and gravel deposit has been operated intermittently since 1941 by Adolph Teichert and Son, Inc. A portable rock plant and batch plant have been located at the pit intermittently. Most of the product from this pit is used on Government contract jobs at Mather Field.

Merritt-Savin Construction Company

Location: sec. 34, T. 10 N., R. 7 E., and sec. 3, T. 9 N., R. 7 E., M.D.M. (projected), on Mississippi Bar, 1 mile southwest of Folsom
Began operating: 1953
Markets: Folsom Dam only
Status in 1953: active
Deposit: river bar and channel (Recent alluvium) and terrace deposit of the Victor formation; predominant aggregate size is minus 9 inches; no overburden
Quarrying equipment: dragline excavators, power shovels and backhoes.
Size of pit: a small part of 161 acres, and 11 to 28 feet deep.
Distance to plant: about 1½ miles
Crushing equipment: gyratory and rod mill
Classification equipment: vibrating screens, inclined trommels, screw classifiers, Wilfley pumps, Whirlcone classifiers, distributor, sizer, sand drag, inclined and radial conveyor belts, and separate 3-inch scalping plant. Some gold is recovered by 2 Pan-American jigs, Yuba jig, and Wilfley tables
Products: sand and concrete aggregate, washed gravel and cobbles.
Rated capacity: 650 tons per hour
Employees: 32

All the products from this operation are now used in the Folsom Dam project. Concrete aggregate is trucked 2 miles east where it is deposited in bunkers which feed onto a 4000-foot inclined conveyor belt that spans the American River by means of a suspension bridge, transporting the aggregate to a 240-yard per hour refrigerated batching plant. Some gold is recovered from the aggregate plant.

McGillivray Construction Company (Main pit)

Location: sec. 15, T. 8 N., R. 5 E., 1 mile west of Perkins
Began operating: 1940
Markets: 90% of product consumed on company contract jobs, 10% retail
Status in 1953: active
Deposit: flood-plain deposit, Victor formation; predominant aggregate size is minus 8 inches; 12 to 18 feet of clay-soil overburden
Quarrying equipment: dragline excavators
Size of pit: 15 acres and 45 feet deep
Distance to plant: about 1½ miles
Crushing equipment: primary jaw and secondary roll
Classification equipment: vibrating screens, bucket elevator, rake classifier, washing screen, and inclined conveyor belts
Products: sand and gravel and road rock
Rated capacity: 150 tons per hour
Employees: 9.

Plant also includes batch plant and hot mix plant. Gold content of the deposit is approximately 2 to 3 cents per cubic yard but is not recovered.

McGillivray Construction Company (Mather Field pit)

Location: secs. 16, 21, and 22, T. 8 N., R. 6 E., M.D.M., 1 mile southwest of Mather Field
Began operating: 1951
Markets: 100% of product consumed on company contract jobs
Status in 1953: intermittently active
Deposit: flood-plain deposit, Victor formation; predominant aggregate size is minus 3 inches; 6 feet of clay-soil overburden
Quarrying equipment: dragline excavator
Size of pit: 16 acres and 40 feet deep
Distance to plant: about ½ mile
Crushing equipment: jaw crushers and roll crushers
Classification equipment: vibrating screens, rotovator, rake classifier, and inclined conveyor belts
Products: sand, gravel and crushed rock
Rated capacity: 150 tons per hour

The rock, batch and hot mix plants are portable. Products from this plant are used on Government contract jobs primarily at Mather Field.

Pacific Coast Aggregates, Inc., (Fair Oaks Plant)

Location: secs. 18, T. 9 N., R. 6 E., and sec. 13, T. 9 N., R. 7 E., M.D.M., south side of American River at the Fair Oaks Bridge.
Began operating: 1909
Markets: wholesale and retail
Status in 1953: active
Deposit: river channel, bar, and terrace deposit, Recent alluvium; predominant aggregate size is minus 10 inches; no overburden
Quarrying equipment: dragline excavators and power shovels
Size of pit: parts of about 7 square miles and 5 to 25 feet deep
Distance to plant: about ½ mile
Crushing equipment: three jaw crushers, two cone and one gyratory.
Classification equipment: Inclined trommel-scrubber, trommels, vibrating screens, eight P.C.A. vibrating screens, screw classifiers, rake classifier
Products: sand and gravel, crushed rock-macadam, ballast, rubble and riprap
Rated Capacity: 350 tons per hour
Employees: 35

An older plant, the Coast Rock and Gravel Company (formerly Natomas Company No. 1 Plant), built in 1909 on the same site, operated until 1939 at which time the present operator began producing sand, gravel, and crushed rock. Present plant equipment also includes separate road rock, batch, and hot mix plants. A considerable amount of aggregate is trucked to Nimbus Dam. The storage bunkers are arranged to discharge onto a central conveyor belt so that any one size or a blend of sizes can be carried to facilities for loading trucks or for loading railroad cars. Other facilities include a maintenance shop and a testing laboratory. Some gold has been recovered.

Perkins Gravel Company

Location: sec. 13, T. 8 N., R. 5 E., M.D.M., $\frac{1}{2}$ mile east of Perkins
Began operating: 1932
Markets: wholesale and retail
Status in 1953: active
Deposit: flood-plain deposit, Victor formation; predominant aggregate size is minus 8 inches; 12 feet of clay-soil overburden
Quarrying equipment: dragline excavators
Size of pit: 50 acres and 50 feet deep
Distance to plant: about 1 mile
Crushing equipment: primary jaw, secondary and tertiary cones and ball mill
Classification equipment: inclined trommel-scrubber, sand drag, vibrating screens, rake classifier, bucket elevators, and inclined conveyor belts
Products: sand and gravel and road rock
Rated capacity: 250 tons per hour
Employees: 15

Plant equipment also includes a batch plant, hot mix plant, road rock plant, slurry plant, and blend bunker. Some by-product gold is recovered.

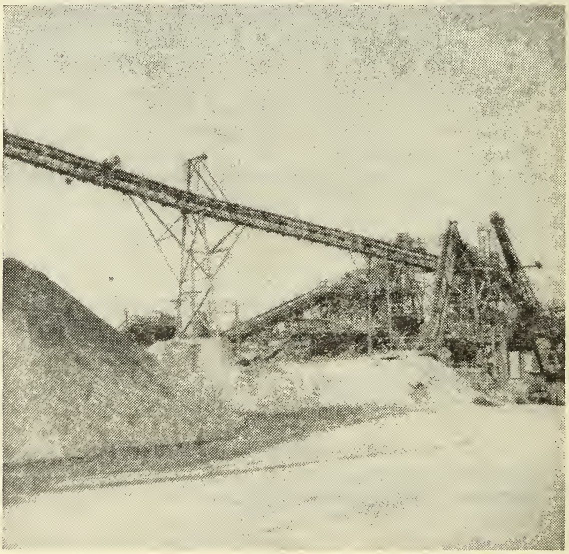

FIGURE 9. Aggregate plant of the Perkins Sand and Gravel Company. *Photo by Thomas E. Gay Jr.*

Reeves Sand Pit

Location: sec. 35, T. 9 N., R. 4 E., M.D.M., near Jibboom Street Bridge, Sacramento
Markets: most of product consumed on company contract jobs
Status in 1953: intermittently active
Deposit: river channel deposit, Recent alluvium; predominant aggregate size is minus $\frac{3}{16}$ inches; no overburden
Crushing equipment: none
Classification equipment: none
Products: sand

Sand is periodically dredged from the channel of the Sacramento River by the U. S. Army Corps of Engineers and deposited at this location. J. R. Reeves utilizes this sand deposit as needed on construction jobs.

Richards Sand Pit

Location: secs. 26 and 35, T. 9 N., R. 4 E., M.D.M., near Jibboom Street Bridge, Sacramento
Markets: wholesale and retail
Status in 1953: intermittently active
Deposit: river channel deposit, Recent alluvium; predominant aggregate size is minus 3/16 inches; no overburden
Crushing equipment: none
Classification equipment: none
Products: sand

Sand is periodically dredged from the channel of the American River by the U.S. Army Corps of Engineers and deposited at the Richards pit, from which it is excavated as needed.

Robert Powell Products

Location: secs. 31 and 32, T. 9 N., R. 5 E., M.D.M., south bank of the American River at end of 24th Street, Sacramento
Began operating: 1923
Markets: wholesale and retail
Status in 1953: active
Deposit: river channel deposit, Recent alluvium, predominant aggregate size is minus 20 mesh; no overburden
Quarrying equipment: suction dredge equipped with 7-inch suction pump.
Size of pit: 700 feet in and along the American River channel; sand deposit ranges from 3 to 18 feet deep
Distance to plant: 80 to 700 feet
Crushing equipment: none
Classification equipment: ¼-inch screen, settling tank, bucket elevator and inclined conveyor belts
Products: mortar and plaster sand
Rated capacity: 150 cubic yards per day
Employees: 8

Plant equipment also includes lime slaking plant.

Robertson's Sand and Gravel

Location: sec. 25, T. 9 N., R. 4 E., M.D.M., at North 12th Street and American River in Sacramento
Began operating: 1948
Markets: wholesale and retail
Status in 1953: active
Deposit: river channel deposit, Recent alluvium; predominant aggregate size is 30-60 mesh; no overburden
Quarrying equipment: suction dredge equipped with 6-inch suction pump
Size of pit: 1000 feet in and along the American River channel; sand deposit ranges from 20 to 25 feet deep
Distance to plant: about 300 feet
Crushing equipment: none
Classification equipment: inclined trommel screen, rake classifier, bucket elevator, screw classifier, and inclined conveyor belts
Products: plaster sand and washed sand fill
Rated capacity: 100 cubic yards per day
Employees: 3

Fines from the bottom of the American River are pumped through 300 feet of 6-inch pipe to the classifying plant.

Sacramento City Gravel Pit

Location: sec. 9, T. 8 N., R. 5 E., M.D.M., east of 58th Street and north and south of Folsom Boulevard, Sacramento
Began operating: before 1932
Markets: product was used for maintenance of Sacramento City roads
Status in 1953: inactive
Deposit: flood-plain deposit, Victor formation; 3½ feet of clay-soil overburden
Quarrying equipment: power shovel
Size of pit: 15 feet deep
Products: pit run and road rock

The City of Sacramento operated this pit between 1932 and 1943, producing pit run, road rock, and asphaltic concrete at various times. The operation was shut down in 1943.

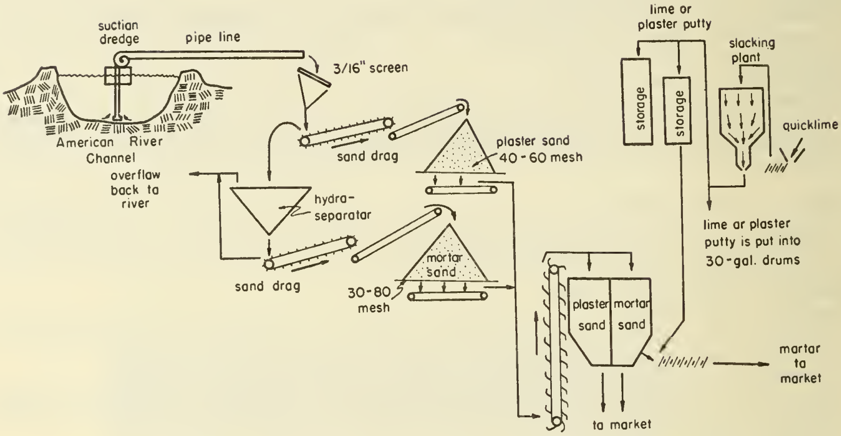
suction dredge
pipe line
3/16" screen
American River Channel
overflow back to river
sand drag
hydra-separator
sand drag
plaster sand 40-60 mesh
mortar sand
30-80 mesh
lime or plaster putty
storage
storage
slacking plant
quicklime
lime or plaster putty is put into 30-gal. drums
plaster sand
mortar sand
to market
mortar to market

FIGURE 10. Flowsheet of the mortar and plaster-sand operations of the Hard Materials Company.

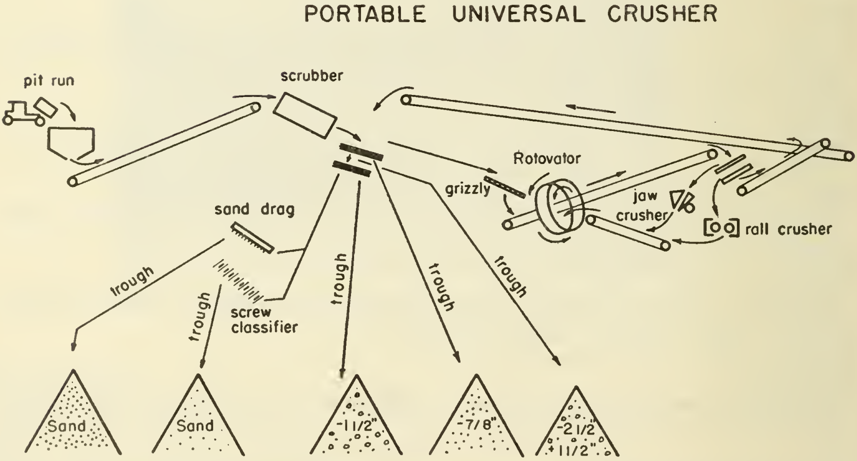
PORTABLE UNIVERSAL CRUSHER
pit run
scrubber
Rotovator
grizzly
jaw crusher
roll crusher
sand drag
screw classifier
trough
trough
trough
trough
trough
Sand
Sand
-1 1/2"
-7/8"
-2 1/2" +1 1/2"

FIGURE 11. Flowsheet of a medium-sized sand and gravel operation.

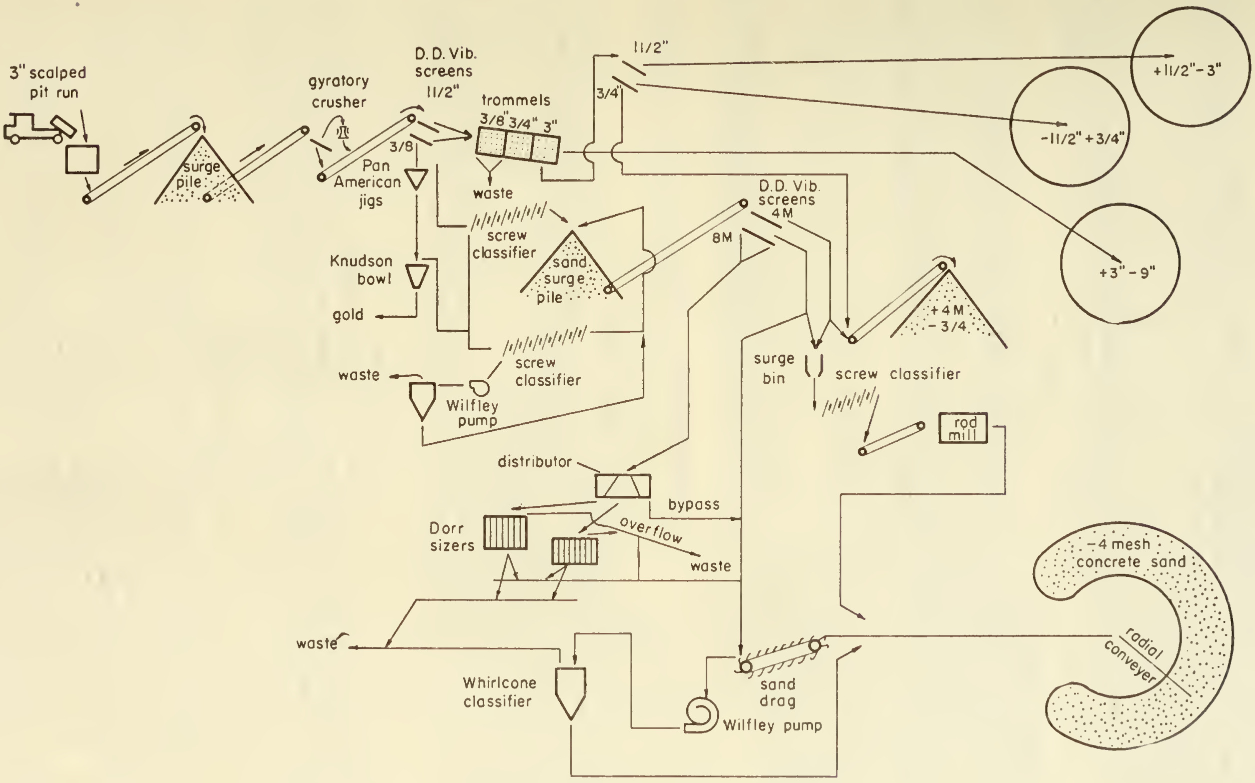
3" scalped
pit run
surge
pile
gyratory
crusher
D.D. Vib.
screens
11/2"
3/8
Pan
American
jigs
Knudson
bowl
gold
trommels
3/8" 3/4" 3"
waste
screw
classifier
sand
surge
pile
screw
classifier
waste
Wilfley
pump
11/2"
3/4"
+11/2"-3"
-11/2" +3/4"
+3"-9"
D.D. Vib.
screens
4M
8M
surge
bin
screw classifier
+4M
-3/4
rod
mill
distributor
bypass
Dorr
sizers
overflow
waste
waste
Whirlcone
classifier
Wilfley pump
sand
drag
-4 mesh
concrete sand
radial
conveyer

FIGURE 12. Flowsheet of a large sand and gravel operation.

Sacramento City Sand Pit

Location: sec. 22, T. 8 N., R. 4 E., M.D.M., Miller Park, Sacramento
Began operating: 1951
Markets: variable
Status in 1953: Intermittently active
Deposit: river channel deposit, Recent alluvium; predominant aggregate size is minus $\frac{3}{16}$ inches; no overburden
Quarrying equipment: power shovel
Crushing equipment: none
Classification equipment: none
Products: sand

Sand was pumped from the channel of the Sacramento River by the U. S. Army Corps of Engineers. The City of Sacramento permits construction companies to haul sand from this site on a royalty basis.

Sacramento County Pit

Location: sec. 31, T. 7 N., R. 6 E., M.D.M., $\frac{1}{4}$ mile northeast of Elk Grove
Began operating: 1930
Markets: used on county roads
Status in 1953: intermittently active
Deposit: fluviatile deposit, Laguna formation; predominant aggregate size is minus $1\frac{1}{2}$ inches; 5 feet of clay-soil overburden
Quarrying equipment: power shovel
Size of pit: 4 to 5 acres and 12 feet deep
Crushing equipment: none
Classification equipment: none
Products: pit run road rock

The County of Sacramento operates this pit intermittently for use on county roads. Located at this site is an old hot mix plant which is no longer used.

Signal Depot Gravel Pit

Location: sec. 24, T. 8 N., R. 5 E., M.D.M., $\frac{1}{4}$ mile east of U. S. Army Signal Depot, Sacramento
Began operating: 1941
Markets: all of product consumed on contract jobs
Status in 1953: intermittently active
Deposit: flood plain deposit, Victor formation; predominant aggregate size is minus $3\frac{1}{2}$ inches; 10 to 20 feet clay-soil overburden
Quarrying equipment: dragline excavator
Size of pit: 800 by 600 feet and 45 feet deep
Products: sand and gravel fill material

This pit was developed by Adolph Teichert and Son, Inc. to provide fill material for a Government contract job at the U. S. Army Signal Depot. The pit is intermittently worked for fill material.

Sand, Molding

Molding sand, which was consumed by foundries in the Sacramento area, was sporadically produced in Sacramento County between 1919 and 1949. Virtually all of this production, particularly in recent years, was from the Cannon and Company property near Ben Ali siding in North Sacramento. At this property, so-called Sacramento red molding sand formed the top layer of Quaternary alluvium underlying the area of the company's clay processing plant. The sand was removed by bulldozer during the winter months and was hauled by truck directly to the foundries (Wright 1948, p. 58). In 1949, however, Cannon's deposit was depleted and there has been no recorded production of molding sand in Sacramento County since that date.

Most of the Sacramento Red production was consumed in the local Southern Pacific foundries, where it was used chiefly in casting gray iron car wheels and engine parts (Wright 1948, p. 58). Since 1949, the Southern Pacific foundries in Sacramento have obtained Santa Ana heavy and medium molding sands from Santa Ana in southern California. The Santa Ana molding sands are used for casting wheels, gray iron castings and brake shoes.

Sandstone

According to Watts (1890, p. 510), sandstone from the Ione formation was quarried in Sacramento County, previous to 1889, 1 mile above the old wire bridge across the Cosumnes River in T. 8 N., R. 8 E., M.D.M. Sandstone from this quarry was used for trimming the Court House and in construction of the building which was occupied by the Post Office at Sacramento in 1890. The quarry has apparently been idle since 1890.

Silver

During 1951, silver valued at $3,689 was produced in Sacramento County, primarily as a by-product from gold dredging operations. Minor amounts of placer silver are also recovered from a few sand and gravel operations. Generally, the amount of silver produced in Sacramento County during any year is proportional to the amount of placer gold produced.

Placer silver in this county has a similar origin to that of placer gold. Silver-bearing zones, including the Mother Lode system of gold-quartz veins, were eroded, and the silver, which is usually alloyed with gold, was freed and transported by river and stream action and deposited in Tertiary and Quaternary sand and gravel deposits.

MINERAL PROCESSING

Concrete Building Blocks

At the present time there are two concerns in Sacramento that manufacture concrete building blocks: the Hokanson Building Block Company on Power Inn Road and the Sacramento Pumice Brick and Tile Company at 2731 Stockton Boulevard. Between the two companies, over one hundred different sizes of building blocks and concrete veneer slabs are manufactured. These products are marketed in central California and transported by means of rail and truck.

Raw materials for these operations consist of cement and sand which are purchased locally, and pumice which is obtained from Glass Mountain in Modoc County. The sand and pumice are mixed with cement and water in a mixer. This mixture is placed in a brick machine which presses the blocks into shape. The pressed blocks are steam-cured for about 24 hours and further cured for about 30 days in the plant yard.

Concrete Pipe

In Sacramento, at the present time, there are two companies manufacturing concrete sewer and drain pipe and culverts: the Western Concrete Pipe Company, Inc., on Power Inn Road and the United Concrete Pipe Corporation on Eastern Avenue. These concrete products are marketed by railroad and truck in central California.

Raw materials for these operations consist of cement, sand, and minus $\frac{7}{8}$-inch gravel, all of which is obtained locally. The largest of the concrete pipe, which is reinforced with steel mesh, is manufactured in 12-foot sections with a diameter ranging from 64 to 78 inches. The pipes are initially steam-cured and further curing is done in the plant yard.

Perlite

The Robertson Sand and Gravel Company at 1061 Vine Street, Sacramento, markets expanded perlite in the Sacramento area. The perlite expanding plant was originally located in North Sacramento but the company is now in the process of moving the plant to the site of the sand plant on the American River.

Crude perlite which has been ground to about 16 mesh is obtained from a deposit in Nevada. Thus far, the main use of the expanded perlite in Sacramento County has been as a lightweight aggregate in plaster.

Vermiculite

The California Zonolite Company operates a vermiculite exfoliation plant in Sacramento. Approximately 500 tons of crushed vermiculite are shipped to the Sacramento plant each month from Libby, Montana.

At the local plant, vermiculite is expanded in two furnaces. The expanded vermiculite is then sized by screens and air separators and bagged in paper bags for shipment to market. Expanded vermiculite from the plant is used as plaster and finish aggregate, acoustical material, insulating and industrial fill, in high temperature cement and in concrete floors.

MINERAL UTILIZATION

A wide variety of mineral substances are used by many concerns in Sacramento County in addition to those described under the mineral commodity sections of this report. Virtually all of these mineral substances are imported into Sacramento County from other counties and states in a refined or semi-refined condition.

Wineries in this county utilize bentonite and diatomaceous earth for filtering wine. In the manufacture of paint, varnish and lacquers, oxides of titanium, zinc and iron as well as carbonates of calcium and lead are used. Some diatomite is also used by the paint industry for filtering purposes. Dental laboratories consume many mineral products including gold, silver, mercury, platinum, clays, graphite, gypsum, pumice and pumicite.

Gypsum and mica as well as other mineral commodities are used by nurseries as soil conditioners. Fertilizer companies consume rather large amounts of inorganic chemicals including potassium chloride, ammonium nitrate and phosphoric acid.

For the production of ice, ice cream and other dairy products, appreciable quantities of ammonia, ammonium chloride, salt, sodium carbonate, calcium chloride and lime are necessary.

Photoengraving concerns consume a wide variety of mineral products including copper, graphite, iodine, magnesium, potassium salts, sodium carbonate, calcium chloride, pumice, talc and zinc.

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TABULATED LIST OF SACRAMENTO COUNTY MINERAL DEPOSITS

Sacramento County mineral deposits are listed in alphabetical order by commodity in the following table. The number in the first column refers to the map, plate 2, in pocket.

References given in the last column refer to the bibliography accompanying this report. Only the last name of the author is given. The first number after each name is the abbreviated date of publication as given in the bibliography; the second number, that following the colon, is the page reference.

CLAY AND CLAY PROCESSING

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	LOCATION T.	LOCATION R.	LOCATION B & M	REMARKS
	Bundock Stoneware Works		Not determinable				This plant, which was located in the eastern suburbs of Sacramento in 1906, manufactured butter jars, churns, bean-pots, jugs, milk crocks, poultry-fonts, water jars and flower pots. The clay was obtained from a deposit north of the Consumnes River, 2 miles east of Bridge House in N$\frac{1}{4}$ of SE$\frac{1}{4}$ of sec. 2, T. 7 N., R. 8 E., M.D.M. This company suspended operations between 1920 and 1925. (Aubury 06:225; Boalich 20:91)
	California Art Tile Corporation	Box 1116, Richmond	Not determinable				Herein
1	Cannon and Company (Sacramento Clay Products Company)	N. 13th and El Camino Ave., North Sacramento	22	9N	5E	MD	(Waring 19:404; Boalich 20:91; Logan 25:2-3; Dietrich 28:183; herein)
1A	Clay pit No. 1	Van Vleck Ranch, Sloughhouse	2	7N	8E	MD	
1B	Clay pit No. 2		2, 3	7N	8E	MD	
1C	Clay pit No. 3		11	7N	8E	MD	
	Capital Sewer Pipe Works		-	-	-	-	See H. C. Muddox Company. (Watts 90:509-510; Crawford 94:383; Crawford 96:617; Aubury 06:225: Boalich 20:91)
	Fountain Brothers' Brickyard		Not determinable				This brickyard began operating in 1879 and supplied local and San Francisco markets. During 1896, one million bricks were produced. Operations were suspended previous to 1906. (Watts 90:508-509; Crawford 94:383; Crawford 96:617)
	Grover Russi clay pit		Not determinable				Gladding McBean and Company produced raw clay from a deposit near White Rock from 1928 to 1930.

CLAY AND CLAY PROCESSING (cont'd)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
2	Harrison Fait	1950 Howe Avenue, North Sacramento,	27	9N (Projected)	5E	MD	Herein
3	H. C. Muddox Co. (Muddox Pottery Company, Capital Sewer Pipe Works)	30th and L Streets, Sacramento	-	-	-	-	(Watts 90:509-510; Crawford 94:383; Crawford 96:617; Aubury 06:225; Waring 19:403; Boalich 20:91; Logan 25:10; Dietrich 28:186; herein)
	Independent Pressed Brick Co.		Not determinable				This company, which was located on the east bank of the Sacramento River just above the Southern Pacific Railroad shops in Sacramento during 1915, manufactured sand-lime bricks. Plant capacity was 12,000 bricks daily. Plant suspended operations previous to 1920. (Waring 19: 402-403)
	Kreuzberger and Harvie's Brickyard		-	-	-	-	See Ryan Brickyard (Crawford 96:617)
	Muddox Pottery Co.		-	-	-	-	See H. C. Muddox Company. (Waring 19:403; Dietrich 28:186)
	Natoma Clay Co. (Natomas Company of California)		Not determinable				(Logan 25:3; Dietrich 28:186; herein)
	Natomas Company of California		Not determinable				See Natoma Clay Company (Logan 25:3)
4	Panama Pottery Co.	4421 - 24th Street Road, Sacramento	-	-	-	-	(Waring 19:403; Boalich 20:91; Logan 25:7-9; Dietrich 28:187-188; herein)

CLAY AND CLAY PROCESSING (cont'd.)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Riverside Brick Yard (Sacramento Transportation Co. Brickyard)		-	-	-	-	See Sacramento Brick Co. (Waring 19:403-404; Boalich 20:91)
	Ryan Brickyard		-	-	-	-	This brickyard, which was located at 13th and Y Streets in Sacramento, was established in 1854, and up to 1870, not only supplied the local market, but also San Francisco. After 1870 the local market consumed all the production. The bricks were hand-made and burned in open field kilns. Oak wood was used for fuel. Two to three million bricks were produced per annum. Operations were suspended between 1896 and 1906. (Watts 90:508; Crawford 94:383; Crawford 96:617)
5	Sacramento Brick Co. (Riverside Brick Yard, Sacramento Transportation Co. Brickyard)	Riverside Boulevard, Sacramento	27 34	8N	4E	M.D.	(Logan 25:9; Dietrich 28:188-189; herein)
	Sacramento Clay Products Co.		-	-	-	-	See Cannon and Co. (Waring 19:404; Boalich 20:91)
	Sacramento Clay Products Co.		-	-	-	-	See Cannon and Co. (Waring 19:404; Boalich 20:91)
	Sacramento Sand Brick Co.		-	-	-	-	See Independent Pressed Brick Co.
	Sacramento Transportation Co. Brickyard		-	-	-	-	See Riverside Brick Yard (Watts 90:506-508; Crawford 94:383; Crawford 96:617; Aubury 06:253)

CLAY AND CLAY PROCESSING (cont'd.)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	Southern Pacific Fire-brick Works		Not determinable				This department of the Southern Pacific Railroad shops did not manufacture commercial bricks, as their product was consumed by the company. White and blue clay was purchased from clay deposits near Ione in Amador County. Annual capacity was 150,000 bricks in 1909. Operations were suspended previous to 1915. (Aubury 06:225-226)
	Valley Brick Co.		Not determinable				In 1928, the plant and pit were located 2 miles southeast of Sacramento near the Southern Pacific and Central California Traction Company line to Stockton. Common red bricks were manufactured at the company plant. This operation was suspended in 1937. (Dietrich 28:189)
	Western Refractories Co.		-	-	-	-	See White Rock pit
6	White Rock pit	Gladding Brothers Mfg. Co. South Third and Keyes St., San Jose 12	30	9N	8E	MD	Herein

GOLD-LODE

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
7	Dorian	Dexa S. Paul c/o Sacramento County Court House, Sacramento	4	8N	8E	MD	May have been active during 1894 and possibly during the 1930's. A southeast adit has been driven along a 3 to 4 foot quartz vein in slate. See M. E. Strait Ranch. (Crawford 94:226; Logan 25:16)
8	E. L. Butler Ranch	S. H. Cavitt, c/o County Court House, Sacramento	20	9N	8E	MD	Considerable surface mining and shallow work was done previous to 1925. The quartz vein, which is up to 5 feet in thickness, has a general northwest strike and a fairly steep east dip. (Logan 25:15)
9	Evanis (Broder)	Ida Evanis Estate, Folsom	N½ 31	10N	8E	MD	Herein
	M. E. Strait Ranch		4	8N	8E	MD	On this ranch, several shallow shafts were sunk previous to 1925. The richest gold concentrations were found along a vein at the contact of a dike and the black slate. In 1916, $8,200 in gold was produced from a 30-foot ore shoot in this area. Some work was probably also done during the early 1930's. (Logan 25:16)
	Milgate		Not determinable				A pocket gold mine that yielded a small amount of gold several year previous to 1894. The mine was located in the Walltown Mining District. May have been included in description of M. E. Strait Ranch. (Crawford 94:227; Logan 25:16)
10	Unknown	Margaret and Eleanor Schnerr, 113 Jordan Street, Santa Cruz	16	9N	8E	MD	Shallow workings on a northwest-trending quartz vein. This work may have been done during the early 1930's.

GOLD-LODE (cont'd.)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
11	Walltown	C. J. and Arthur J. Smith, c/o Sacramento County Court House, Sacramento	4	8N	8E	MD	Probably included in description of M. E. Strait Ranch as having been mined previous to 1925. Some work was probably also done during the early 1930's. Since early 1952, Carl H. Pearson of Sacramento has been intermittently working the mine in search of "pocket gold". Up to December 1953, no gold had been produced. A quartz vein strikes northwest in Mariposa slate. (Logan 25:16)
	Zimmerman		Not determinable				Located about 5 miles southeast of Folsom; may have been active in 1894. Development work at that time consisted of a 30-foot shaft. (Crawford 94:227; Crawford 96:318).

GOLD-PLACER

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Antone Rodger		Not determinable				At Sulky Flat on the Natoma Grant; worked during 1894. (Crawford 94:227)
	Biggs		Not determinable				Some placer gold mining was done by Frank Woodward and partner during 1932. 5 miles east of Mills.
	Biglow		Not determinable				Robert H. Swab of Sacramento worked a placer mine on the Biglow property on the American River 18 miles from Sacramento, in 1933 and 1934. Equipment consisted of a power shovel, trucks and sluices. (Bradley 35:21)
	Buckeye Flat		Not determinable				This mine, located on Buckeye Flat, $2\frac{1}{2}$ miles southwest of Folsom, may have been active in 1896. (Crawford 96:316)
	Doc Yen		Not determinable				This claim, situated on the Natoma Grant, was worked by persons of Chinese descent who stripped the gravel to a depth of 33 feet in 1894. (Crawford 94:226)
	Donnelly Reservoir		Not determinable				$2\frac{1}{2}$ miles southeast of Folsom. Worked by a Chinese company in 1896. (Crawford 96:316)
	Eckardt		Not determinable				5 miles east of Folsom in the Willow Springs District. Worked from 1894 to 1896. (Crawford 94:226; Crawford 96:316)
	Folsom Water Power Co.		Not determinable				Company was preparing to mine the channel of American River from the old dam above Folsom prison for a distance of 2 miles downstream in 1894. (Crawford 94:226; Crawford 96:317)
	Giddings, A. F.		Not determinable				Surface gravels were placer mined in 1934 on Mississippi Bar by steam shovels and trucks. (Bradley 35:21)

GOLD-PLACER (cont'd.)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	Humbug Hill		Not determinable				$1\frac{1}{4}$ miles southeast of Folsom. Worked by Chinese persons in 1896. (Crawford 96:317)
	Jordan		Not determinable				On the north bank of the Consumnes River. Worked by ground sluicing in 1894. (Crawford 94:216)
	Jumbo		Not determinable				A dry-land dredger operated on Carson Creek, half a mile west of Clarksville in 1924.
	Keefe and Mahone		Not determinable				On the Natoma Grant in the Willow Springs District 5 miles east of Folsom. Worked in 1894. (Crawford 94:227)
	Larson Brothers		Not determinable				Surface gravels were placer mined in 1934 on Mississippi Bar by steam shovels and trucks. (Bradley 35:21)
	Mahoney and Keefe		Not determinable				Formerly a large hydraulic mine; was worked by ground-sluice methods in 1896. Property was located 2 miles south of Folsom. (Crawford 96:317)
	Mendota		Not determinable				Preparations were being made in 1896 to mine the channel of the American River a short distance below Folsom. (Crawford 96:317)
	Old De Rosa		Not determinable				On the Natoma Grant at Sulky Flat; worked in 1894. (Crawford 94:227)
	Perry		Not determinable				3 miles southeast of Folsom; worked by ground-sluicing in 1896. (Crawford 96:318)
	Rebel Hill		Not determinable				On Rebel Hill, $3\frac{1}{2}$ miles south of Folsom; worked by ground sluicing in 1896. (Crawford 96:318)
	Rogers		Not determinable				$2\frac{1}{2}$ miles southwest of Folsom; active during 1896. (Crawford 96:318)

GOLD-PLACER (cont'd.)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Rollins		Not determinable				3 miles south of Folsom; worked by ground sluicing in 1896. Bank was then 20 to 40 feet high. (Crawford 96:318)
	Salvador		Not determinable				3 miles south of Folsom; may have been active during 1896. (Crawford 96:318)
	Sulky Flat		Not determinable				1½ miles southwest of Folsom; worked in 1896 by Chinese. (Crawford 96:318)
	Van Vleck Brothers'		Not determinable				W. S. Davis and J. A. Kimmel placer mined gravels 1 mile east of Michigan Bar during 1934. (Bradley 35:21)
	Weeks Gravel		Not determinable				Some gold was recovered from surface placers on the J. Weeks farm near Mills in 1933.
	Willow Spring Hill		Not determinable				2 miles east of Folsom; worked by ground sluicing in 1896. (Crawford 96:318)
	Young, Clarence		Not determinable				C. Young worked a dryland plant and 1¼-yard bucket in the vicinity of Sacramento during 1939.

GOLD-DREDGING

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	Ashburton Mining Co. (New England Exploration Co.)		Not determinable				Second company to begin dredging operations in Sacramento County. Operated 2 dredges on and in the vicinity of Sailor's Bar. Dredging commenced on March 1, 1900, and by 1913, both dredges had been dismantled. (Doolittle, 05:36, 95; Aubury 10:178; Logan 19:27)
	Bohnett, F. O.		Not determinable				Operated a portable non-floating Peerless Gold Recovery unit equipped with 4 Ainlay bowls and a dragline equipped with a one-cubic-yard bucket. Worked for several months during 1939 and 1940 and continually throughout 1941 on the Hutchison property in the Cosumnes River district.
	Capital Dredging Co.	351 California Street San Francisco 4	25,26	9N	7E	MD	(Logan 35:21; Averill 46:280; herein).
	Carson Creek Dredging Co. Ltd.		Not determinable				Company operated a dragline excavator equipped with a 1-3/4 cubic yard bucket and a washing plant on the Martin Quinn Ranch from Sept. 11, 1940, to Feb. 5, 1941, when the operation was taken over by the Northwest Development Co. Dredging operations were suspended in 1941. (Averill 46: 280-281)
	Climax Dredging Co.		Not determinable				Operated dragline dredge from Jan. 1 to April 8, 1941, on the J. Vincent property near Folsom. (Averill 46:281)
	Colorado Pacific Gold Dredging Co.		Not determinable				Company commissioned the first gold dredge in Sacramento County in April of 1899 and was later absorbed in 1908 by the Natoma Development Co. Two dredges were operated on Michigan Bar. (Doolittle 05:95-96: Aubury 10:178; Logan 19:27)
	Cosumnes Gold Dredging Co.	465 California Street San Francisco 4	12	7N	7E	MD	(Averill 46:281; herein)
	Doan Mining		Not determinable				(Crawford 96:226; herein)

GOLD-DREDGING (cont'd)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	El Dorado Gold Dredging Co.		Not determinable				Operated one dredge in Folsom district, 1905-1909. Company absorbed by Natomas Consolidated in 1909. (Doolittle 05:95; Aubury 10:195)
	Folsom Development Co.		Not determinable				Fourth company to begin dredging operations in Sacramento County. Began dredging in 1904, commissioned a total of six dredges; by the end of 1908, the Natomas Consolidated had purchased all holdings of the company. (Doolittle 05:98; Aubury 10:179, 181, 185, 187, 190)
	Garibaldi, C. R.		Not determinable				Herein
	General Dredging Co.	Natoma	3 (projected)	9N	9E	MD	(Averill 46:281; herein)
	Gold Hill Dredging Co.		Not determinable				(Logan 35:21; herein)
	Hoosier Gulch Placers		Not determinable				(Averill 46:281; herein)
	Humphreys Gold Corp.		Not determinable				(Averill 46:281; herein)
	Lancha Plana Gold Dredging Co.		Not determinable				(Averill 46:281; herein)
	Lobicasa Co.		Not determinable				Operated a dragline dredge from June 5 to Oct. 17, 1941, on the Mahon property in the Cosumnes River district. The dragline was equipped with a $1\frac{1}{2}$ cubic-yard bucket. (Averill 46:281)
	Lord and Bishop		Not determinable				Company operated a dragline dredge on Scott Ranch in the Cosumnes River District near Sloughouse during 1937 and 1938 and recovered nearly $100,000 in gold. From April 1 to July 28, 1937, 100,000 cubic yards of gravel yielded 778 ounces of gold and from January 1 to July 7, 1938, 247,500 cubic yards of gravel yielded 2064 ounces of gold.

GOLD-DREDGING (cont'd.)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Marilyn Mining Co.		Not determinable				Company operated a dragline dredge for short time during 1937 in the Folsom district.
	McKinley, H. W.	Hoxsie property, Folsom district	Not determinable				H. W. McKinley operated a non-floating washing plant from April 15 to Sept. 12, 1940, on the Hoxsie property in the Folsom district.
	McQueen & Downing	Folsom district	Not determinable				Company operated a dragline dredge on Deer Creek in the Folsom district from Sept. 10 to Dec. 17, 1940, and from January 1 to February 14, 1941, (Averill 46:281)
	Mountain Gold Dredging Co.		Not determinable				Herein
	Natomas Development Co.		Not determinable				Company absorbed the holdings of the Syndicate Dredging Co., Colorado Pacific Gold Dredging Co., and the Natomas Vineyard Co. in 1908 and began operating 3 dredges. In 1909 the Natomas Development Co. was consolidated with the Folsom Development Co. and the El Dorado Gold Dredging Co. to form the Natomas Consolidated of California. See Natomas Co. (Aubury 10:195-198)
	Natomas Co.	Natomas Co. Forum Building, Sacramento	2	9N	7E	MD	(Aubury 10:174, 205; Logan 19:20, 21, 27, 29, 97-98; Waring 15:405-413; Laizure 23:21; Logan 25:13-14; Logan 35:21; Averill 46:278; herein)
12	Dredge No. 1		35	9N	6E	MD	(projected) As of Jan. 13, 1954.
12a	Dredge No. 5		27	9N	7E	MD	(projected) As of Jan. 13, 1954.
12b	Dredge No. 6		7	8N	7E	MD	(projected) As of Jan. 13, 1954.
12c	Dredge No. 8		32	9N	7E	MD	(projected) As of Jan. 13, 1954.
12d	Dredge No. 10		8	8N	7E	MD	(projected) As of Jan. 13, 1954.
	Natomas Co. of California						See Natomas Company

GOLD-DREDGING (cont'd.)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	Natomas Consolidated of California						See Natomas Company
	New England Exploration						See Ashburton Mining Co.
	Sacramento Gold Dredging Co.		Not determinable				Company operated a dragline dredge in the Folsom district throughout 1936 until June 1, 1937. The dredge capacity was 5000 cubic yards per day.
	Syndicate Dredging Co.		Not determinable				Company was the third gold dredging company to operate in Sacramento County. Dredging began in the Folsom district in 1901 and in 1908, the Natoma Development Co. absorbed all holdings of the company. See Natoma Development Company. (Aubury 10:178-179)
	Thurman and Wright		Not determinable				Company operated an electrically powered, connected-bucket dredge equipped with 86 6-cubic-foot buckets 3 miles southeast of Sloughhouse continuously from Feb. 8, 1946, to Dec. 24, 1948.
	Wallace Dredging Co.		Not determinable				This company operated an electric, connected-bucket dredge equipped with 71 3-cubic-foot buckets 8 miles west of Ione from January 27 to November 23, 1946.
	Wilkies-Barre Dredging Co.		Not determinable.				Company operated a dredge in the Folsom district. Operations began in November of 1914 and were discontinued in February of 1916. The Natomas Consolidated of California acquired the holdings of this company in March 1916. (Logan 19:27)

GOLD-DRIFT MINES

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	Addison		Not determinable				On the outskirts of Folsom; active in 1896. At that time persons of Chinese descent were sinking a shaft. (Crawford 96:316)
	Blue Ravine		Not determinable				(Crawford 96:316; herein)
	Buckeye Flat Mining Co.		Not determinable				(Logan 25:15; herein)
	Burke		Not determinable				At Rebel Hill, 3 miles southwest of Folsom on the Natoma Grant. Worked in 1894 by 59$\frac{1}{2}$-foot shaft with a 4$\frac{1}{2}$-foot bed of auriferous gravel at the bottom. The gold was flaky and rusty. (Crawford 94:226)
	Cecilia Barrett (Martin Welch)		SW$\frac{1}{4}$ 1 E$\frac{1}{2}$ 2	7N	8E	MD	(Logan 25:15)
	Chinese		Not determinable				About 25 persons of Chinese descent were engaged in drift mining at Folsom in 1894. (Crawford 94:226)
	Finch		Not determinable				At Rebel Hill; worked in 1894. (Crawford 94:226)
13	Gray	Vida A. Russi c/o County Court House Sacramento	NW$\frac{1}{4}$ 18	9N	8E	MD	(Waring 19:413; herein)
	Gray Wing Extension		Not determinable				(Bradley 35:21; herein.)
	Lake Shore		Not determinable				Both white men and men of Chinese descent worked a 4-foot thick auriferous gravel bed in this mine during 1896. The mine was located on Rebel Hill, 3 miles south of Folsom. Development work consisted on four shafts, each 60 feet deep. (Crawford 96:317)

GOLD-DRIFT MINES (cont'd.)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Lawson and White		Not determinable				Two prospect drifts were being driven in 1896. The property was located 1 mile northwest of Folsom on Big Creek. (Crawford 96:317)
	Maben and Nickerson		Not determinable				A prospect shaft was being sunk in 1896 on this property 2 miles south of Folsom. (Crawford 96:317)
	McCue and Company		Not determinable				Company was sinking a 4 by 8 foot prospect shaft in 1894. (Crawford 94:227)
	Perry		Not determinable				On the Natoma Grant in the Willow Springs District 5 miles east of Folsom; worked in 1894. (Crawford 94:227)
	Turner		Not determinable				In Blue Ravine 5 miles from Folsom; active in 1925 and 1926.
	White and Donnelly		Not determinable				On the railroad right-of-way at Folsom; worked from 1894 to 1896. Development work consisted of two 45-foot and several other 40-foot shafts including many feet of drifts and crosscuts. (Crawford 94:227; Crawford 96:318)
	White, Donnelly and Cooney		Not determinable				2½ miles southwest of Folsom. A prospect shaft was being sunk on this property in 1896. (Crawford 96:318)
	Amador and Sacramento Canal Co.		Not determinable				On south side of the Cosumnes River at Michigan Bar. The Columbian Gold Mining Co. was mining this property by hydraulic mining and ground sluicing in 1894. (Crawford 94:226)

GOLD-HYDRAULIC MINING

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	Mahoney and Keefe		Not determinable				2 miles south of Folsom; was a large hydraulic mine previous to 1896. (Crawford 96:317)
	Michigan Bar		Not determinable				(Irelan 88:556; Crawford 96:317; herein).

GRANITIC ROCK

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	David Blower		Not determinable				Granite from this quarry, 2 miles east of Folsom, was quarried between 1878 & 1890 by David Blower. About 15 tons of roughly dressed stone were shipped from this quarry weekly. Most of the product was used for cemetery work and street curbs. (Irelan 88:557)
	Folsom Prison						(Irelan 88:557; Watts 90:511; Crawford 94:386; Aubury 06:47-48; Waring 19:416; herein)

SAND, MOLDING

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	Cannon and Co.	N. 13th and E. El Camino Ave., North Sacramento	22	9N	5E	MD	(Wright 48:58; herein)

SAND AND GRAVEL

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Adams, Gilbert		Not determinable				Produced sand and gravel in 1939 and 1940.
14	American River Sand and Gravel Co.		14	8N	5E	MD	(Logan 25:16; herein)
15	Brighton Sand and Gravel Co.		24	8N	5E	MD	Herein
	Capital Sand and Gravel Co. (Sacramento Sand Co.)		Not determinable				In 1925 operation was located on the north bank of the American River near the old 12th Street bridge. Sand was produced from a sand bar in the American River. Equipment consisted of a 6-inch suction dredge and a stationary screen plant. In 1928 this company ceased operations. (Logan 25:17-18)
	Coast Rock and Gravel Co. (Natomas Consolidated of California)						See Pacific Coast Aggregates, Inc. (Logan 25: 19)
	Construction Materials Co.		Not determinable				Some sand and gravel was produced in 1931.
16	Del Paso Rock Products Co.		1, 12 (projected)	8N	5E	MD	Herein
17	Fair Oaks Gravel Co.		8, 17 (projected)	9N	7E	MD	Herein
18	Haggin Gravel Co. (J. R. Reeves)		32,33 4, 5 (projected)	9N 8N	6E 6E	MD MD	Herein
19	Hard Materials Co.		25	9N	4E	MD	Herein
	Harms Brothers		Not determinable				Produced some sand and gravel in 1947.

SAND AND GRAVEL (cont'd.)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
20	Lentz		35	9N	4E	MD	Herein
	Lord and Bishop		Not determinable				Operated from 1936 to 1938 and again in 1945.
21	Mayhew		10 (projected)	8N	6E	MD	Herein
22	Merritt-Savin Construction Co.		34 3 (projected)	10N 9N	7E 7E	MD MD	Herein
23	McGillivray Construction Co.	Main pit	15	8N	5E	MD	Herein
23a		Mather Field pit	22	8N	6E	MD	Herein
	Mucke Sand and Gravel Co.		Not determinable				Produced sand and gravel continuously from 1934 to 1944 on the southside of the American River between Perkins and Mills.
	Natomas Consolidated of California						See Pacific Coast Aggregates, Inc. (Waring 19:413-415)
24	Pacific Coast Aggregates, Inc. (Natomas Consolidated of California, Coast Rock and Gravel Co.)		18	9N	6E	MD	
			13 (projected)	9N	7E	MD	(Waring 19:413-415; Logan 25:19; herein.)
25	Perkins Gravel Co.		13	8N	5E	MD	Herein
	Pratt Building Material Co.		Not determinable				Sand plant was located on the south side of the American River near 12th St. Sand was dredged from the American River channel by a dragline and washed, screened and stored in bins. In 1926 company suspended operations. (Logan 25:19-20).

SAND AND GRAVEL (cont'd.)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	Pratt Rock and Gravel Co.		Not determinable				Dredger tailings near Folsom were being processed to screenings and crushed rock during 1925. In 1927 company suspended operations. (Logan 25: 20-21)
26	Reeves		35	9N	4E	MD	Herein
27	Richards		26 35	9N	4E	MD	Herein
28	Robert Powell Products		31	9N	5E	MD	
	(Sacramento Mortar and Sand Co.)		32 (projected)				(Logan 25:21; herein)
29	Robertson's Sand and Gravel Co.		25	9N	4E	MD	Herein
	Sacramento Mortar and Sand Co.						See Robert Powell Products. (Logan 25:21)
	Sacramento Sand Co.						See Capital Sand and Gravel Co.
30	Signal Depot		24	8N	5E	MD	Herein
31	Sacramento City		22	8N	4E	MD	Herein
32	Sacramento County		31	7N	6E	MD	Herein
	Soloman, G. W.		Not determinable				Produced some sand and gravel in 1940.

SANDSTONE

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	Michigan Bar		?	8N	8E	MD	(Watts 90:510; herein)

SLATE

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	Latrobe		?	8N	9E	MD	Slate of fair quality crops out in several places in the hills west of Latrobe, notably in T.8N., R.9E., M.D.M. This slate is fine grained, has even cleavage and readily splits into laminae 2 feet square by one-sixteenth of an inch thick. (Watts 90:511)

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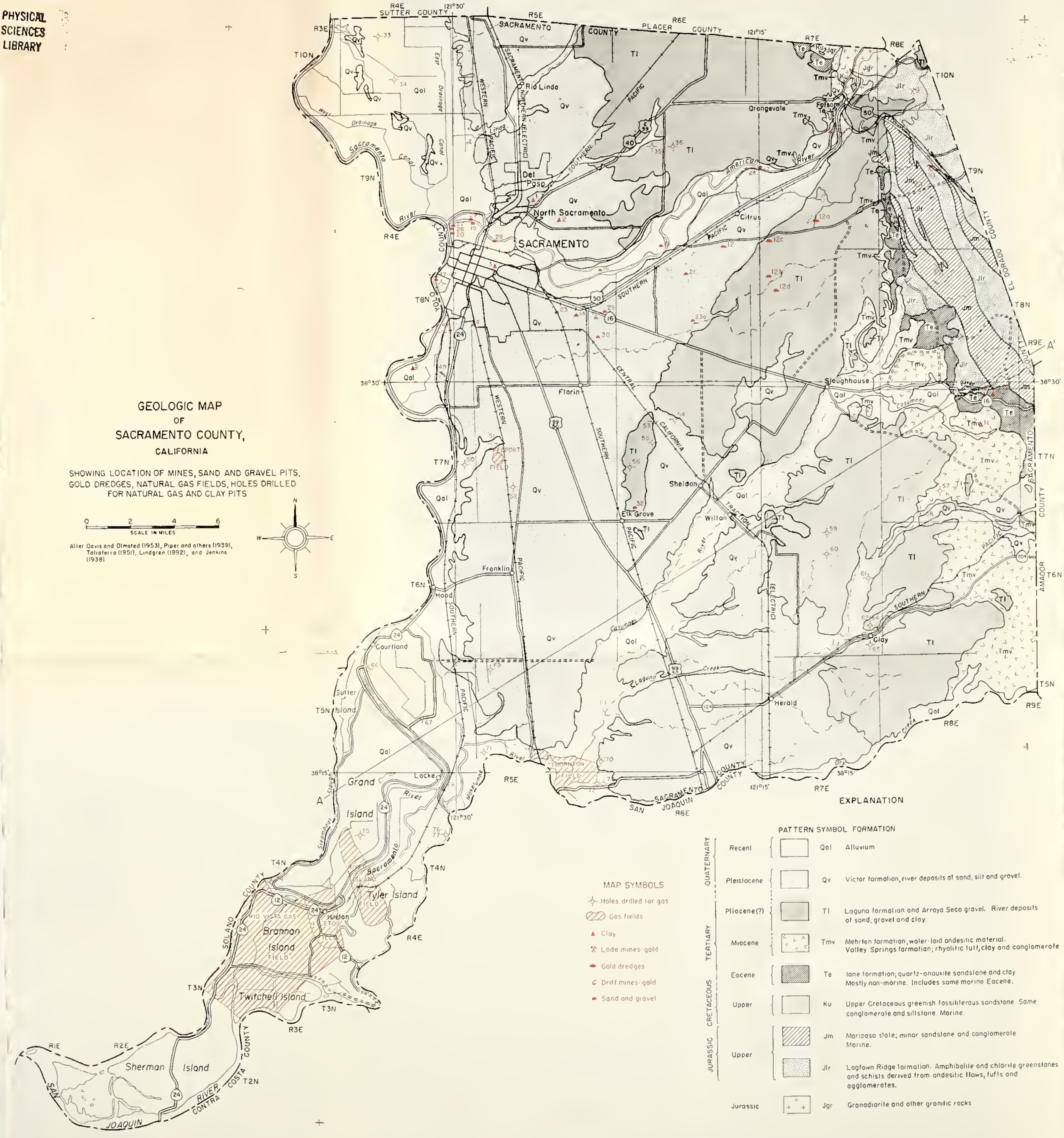

SUTTER COUNTY
SACRAMENTO COUNTY
PLACER COUNTY
EL DORADO COUNTY
AMADOR COUNTY
SAN JOAQUIN COUNTY
SOLANO COUNTY
CONTRA COSTA COUNTY
YOLO COUNTY
R1E
R2E
R3E
R4E
R5E
R6E
R7E
R8E
R9E
T1ON
T9N
T8N
T7N
T6N
T5N
T4N
T3N
T2N
121°30'
121°15'
38°30'
38°15'
Rio Linda
Orangevale
Folsom
Del Paso
North Sacramento
SACRAMENTO
Citrus
Florin
Sloughhouse
Elk Grove
Sheldon
Wilton
Franklin
Hood
Courtland
Clay
Herald
Locke
Isleton
Sutter Island
Grand Island
Tyler Island
Brannon Island
Twitchell Island
Sherman Island
Sacramento River
American River
Cosumnes River
Laguna Creek
Dry Creek
Sacramento Canal
East Drainage Canal
West Drainage
Steamboat Slough
Mokelumne
SOUTHERN PACIFIC
WESTERN PACIFIC
SACRAMENTO NORTHERN (ELECTRIC)
CENTRAL CALIFORNIA TRACTION
FREEPORT FIELD
THORNTON FIELD
RIVER ISLAND FIELD
RIO VISTA GAS FIELD
ISLETON FIELD
TYLER ISLAND FIELD
BRANNON ISLAND FIELD
Qal
Qv
Tl
Tmv
Te
Ku
Jm
Jlr
Jgr
A
A'

GEOLOGIC MAP
OF
SACRAMENTO COUNTY,
CALIFORNIA

SHOWING LOCATION OF MINES, SAND AND GRAVEL PITS, GOLD DREDGES, NATURAL GAS FIELDS, HOLES DRILLED FOR NATURAL GAS AND CLAY PITS

0 2 4 6
SCALE IN MILES

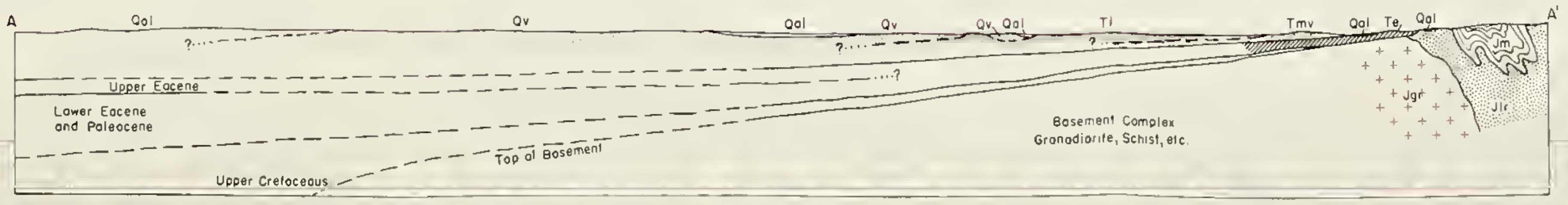
After Davis and Olmsted (1953), Piper and others (1939), Taliaferro (1951), Lindgren (1892), and Jenkins (1938)

MAP SYMBOLS

- ✧ Holes drilled for gas
- ▨ Gas fields
- ▲ Clay
- ✕ Lode mines-gold
- ● Gold dredges
- ∈ Drift mines-gold
- ● Sand and gravel

EXPLANATION

		PATTERN	SYMBOL	FORMATION
QUATERNARY	Recent	☐	Qal	Alluvium
	Pleistocene	☐	Qv	Victor formation, river deposits of sand, silt and gravel.
TERTIARY	Pliocene(?)	▩	Tl	Laguna formation and Arroyo Seco gravel. River deposits of sand, gravel and clay.
	Miocene	☐	Tmv	Mehrten formation; water-laid andesitic material. Valley Springs formation; rhyolitic tuff, clay and conglomerate
	Eocene	▨	Te	Ione formation; quartz-anauxite sandstone and clay Mostly non-marine. Includes some marine Eocene.
CRETACEOUS	Upper	☐	Ku	Upper Cretaceous greenish fossiliferous sandstone Some conglomerate and siltstone. Marine.
JURASSIC	Upper	▨	Jm	Mariposa slate; minor sandstone and conglomerate Marine.
		░	Jlr	Logtown Ridge formation. Amphibolite and chlorite greenstones and schists derived from andesitic flows, tuffs and agglomerates.
	Jurassic	☐	Jgr	Granodiorite and other granitic rocks


A
A'
Qal
Qv
Qal
Qv
Qv, Qal
Tl
Tmv
Qal
Te,
Qal
Jm
Jgr
Jlr
?
Upper Eocene
Lower Eocene and Paleocene
Basement Complex Granodiorite, Schist, etc.
Top of Basement
Upper Cretaceous

SECTION A-A'

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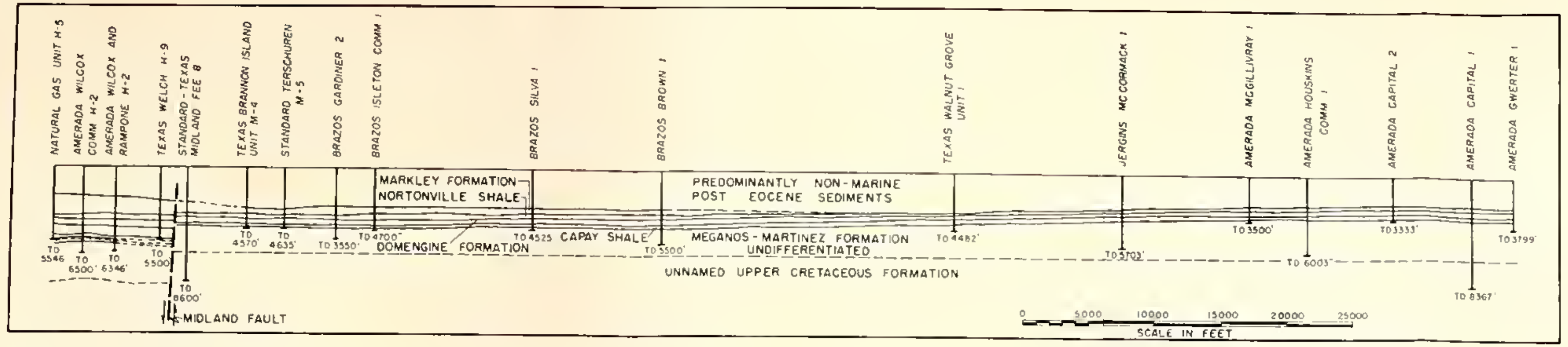
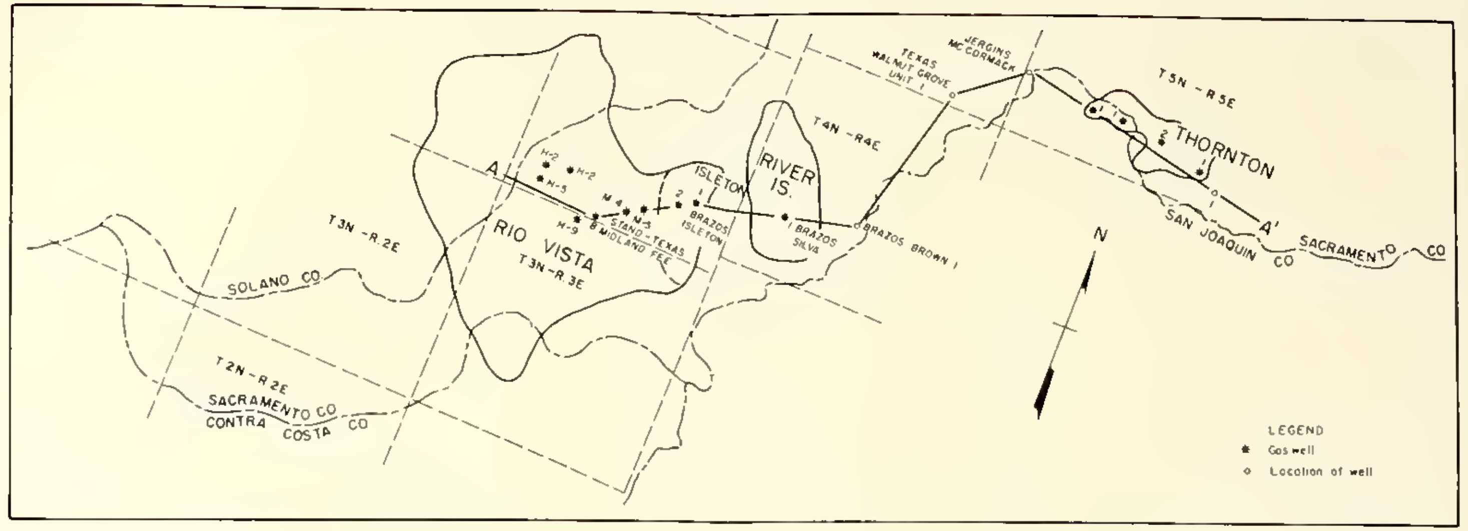
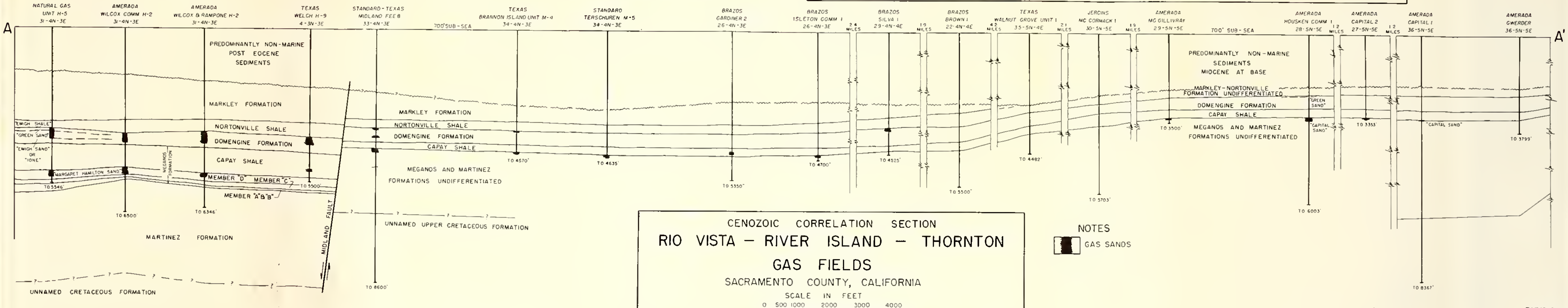

NATURAL GAS UNIT H-5
AMERADA WILCOX COMM H-2
AMERADA WILCOX AND RAMPONE H-2
TEXAS WELCH H-9
STANDARD-TEXAS MIDLAND FEE 8
TEXAS BRANNON ISLAND UNIT M-4
STANDARD TERSCHUREN M-5
BRAZOS GARDINER 2
BRAZOS ISLETON COMM 1
BRAZOS SILVA 1
BRAZOS BROWN 1
TEXAS WALNUT GROVE UNIT 1
JERGINS MC CORMACK 1
AMERADA MCGILLIVRAY 1
AMERADA HOUSKINS COMM 1
AMERADA CAPITAL 2
AMERADA CAPITAL 1
AMERADA GWERTER 1
MARKLEY FORMATION
NORTONVILLE SHALE
PREDOMINANTLY NON-MARINE POST EOCENE SEDIMENTS
DOMENGINE FORMATION
CAPAY SHALE
MEGANOS-MARTINEZ FORMATION UNDIFFERENTIATED
UNNAMED UPPER CRETACEOUS FORMATION
MIDLAND FAULT
TD 5546
TD 6500'
TD 6346'
TD 5500
TD 8600'
TD 4570'
TD 4635'
TD 5550'
TD 4700"
TD 4525
TD 5500'
TD 4482'
TD 5703'
TD 3500'
TD 6003'
TD 3333'
TD 8367'
TD 3799'
0 5000 10000 15000 20000 25000
SCALE IN FEET


T3N-R2E
T2N-R2E
T3N-R3E
T4N-R4E
T5N-R5E
RIO VISTA
ISLETON
RIVER IS.
THORNTON
A
A'
H-2
H-2
H-5
H-9
M-4
M-5
8 STAND-TEXAS MIDLAND FEE
2
1 BRAZOS ISLETON
1 BRAZOS SILVA
BRAZOS BROWN 1
TEXAS WALNUT GROVE UNIT 1
JERGINS MC CORMACK
SOLANO CO
SACRAMENTO CO
CONTRA COSTA CO
SAN JOAQUIN CO
SACRAMENTO CO
N
LEGEND
● Gas well
○ Location of well


A
A'
NATURAL GAS UNIT H-5 31-4N-3E
AMERADA WILCOX COMM H-2 31-4N-3E
AMERADA WILCOX & RAMPONE H-2 31-4N-3E
TEXAS WELCH H-9 4-3N-3E
STANDARD-TEXAS MIDLAND FEE 8 33-4N-3E
700'SUB-SEA
TEXAS BRANNON ISLAND UNIT M-4 34-4N-3E
STANDARD TERSCHUREN M-5 34-4N-3E
BRAZOS GARDINER 2 26-4N-3E
BRAZOS ISLETON COMM 1 26-4N-3E
2.4 MILES
BRAZOS SILVA 1 29-4N-4E
1.9 MILES
BRAZOS BROWN 1 22-4N-4E
4.2 MILES
TEXAS WALNUT GROVE UNIT 1 35-5N-4E
2.1 MILES
JERGINS MC CORMACK 1 30-5N-5E
1.9 MILES
AMERADA MC GILLIVRAY 29-5N-5E
700' SUB-SEA
AMERADA HOUSKEN COMM 1 28-5N-5E
1.2 MILES
AMERADA CAPITAL 2 27-5N-5E
1.2 MILES
AMERADA CAPITAL 1 36-5N-5E
AMERADA GWERDER 36-5N-5E
PREDOMINANTLY NON-MARINE POST EOCENE SEDIMENTS
MARKLEY FORMATION
"EMIGH SHALE"
"GREEN SAND"
"EMIGH SAND" OR "IONE"
NORTONVILLE SHALE
DOMENGINE FORMATION
CAPAY SHALE
MEGANOS FORMATION
MARGARET HAMILTON SAND
MEMBER "D"
MEMBER "C"
MEMBER "A" "B" "B"
MARTINEZ FORMATION
UNNAMED CRETACEOUS FORMATION
MIDLAND FAULT
MEGANOS AND MARTINEZ FORMATIONS UNDIFFERENTIATED
UNNAMED UPPER CRETACEOUS FORMATION
PREDOMINANTLY NON-MARINE SEDIMENTS MIOCENE AT BASE
MARKLEY-NORTONVILLE FORMATION UNDIFFERENTIATED
"GREEN SAND"
"CAPITAL SAND"
"CAPITAL SAND"
TD 5546'
TD 6500'
TD 6346'
TD 5500'
TD 8600'
TD 4570'
TD 4635'
TD 5350"
TD 4700"
TD 4525'
TD 5500"
TD 4482'
TD 5703'
TD 3500'
TD 6003'
TD 3333'
TD 8367'
TD 3799'
NOTES
▮ GAS SANDS

CENOZOIC CORRELATION SECTION

RIO VISTA – RIVER ISLAND – THORNTON GAS FIELDS

SACRAMENTO COUNTY, CALIFORNIA

SCALE IN FEET
0 500 1000 2000 3000 4000

VERTICAL AND HORIZONTAL SCALES ARE EQUAL EXCEPT WHERE GAPS ARE SHOWN

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Vol. 51 JULY 1955 No. 3

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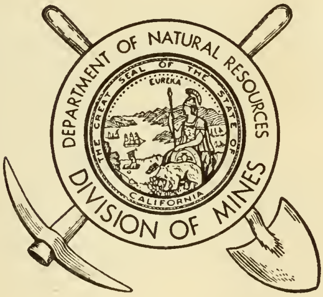
OF
MINES AND GEOLOGY



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In addition to oral conferences in the offices of the Division of Mines, information concerning the mineral resources, mineral industry, geology, and mining operations of California is distributed to the public by means of publications, monthly releases, and letters. Each letter of inquiry received by the Division is answered by the technical staff member best qualified to do so.

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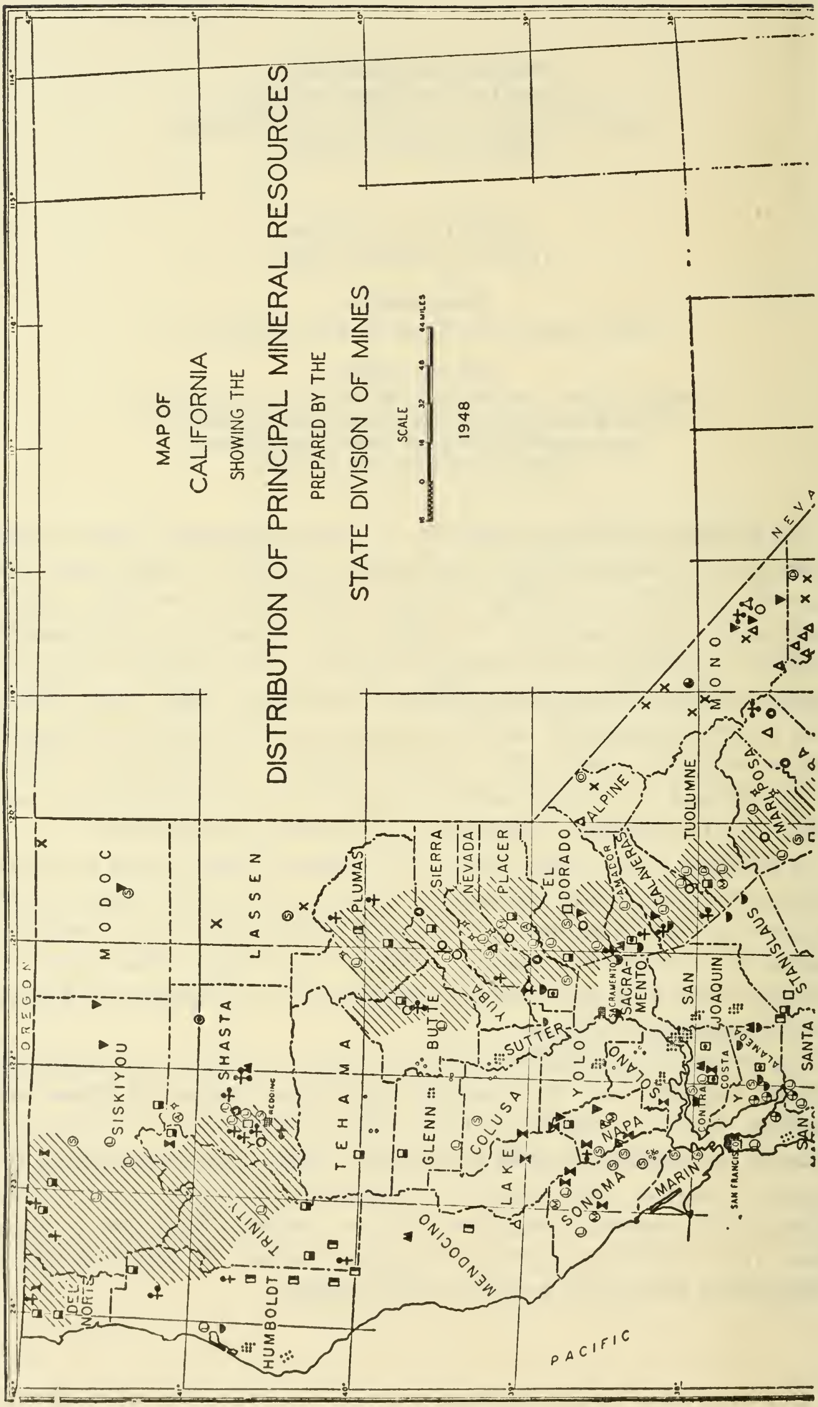
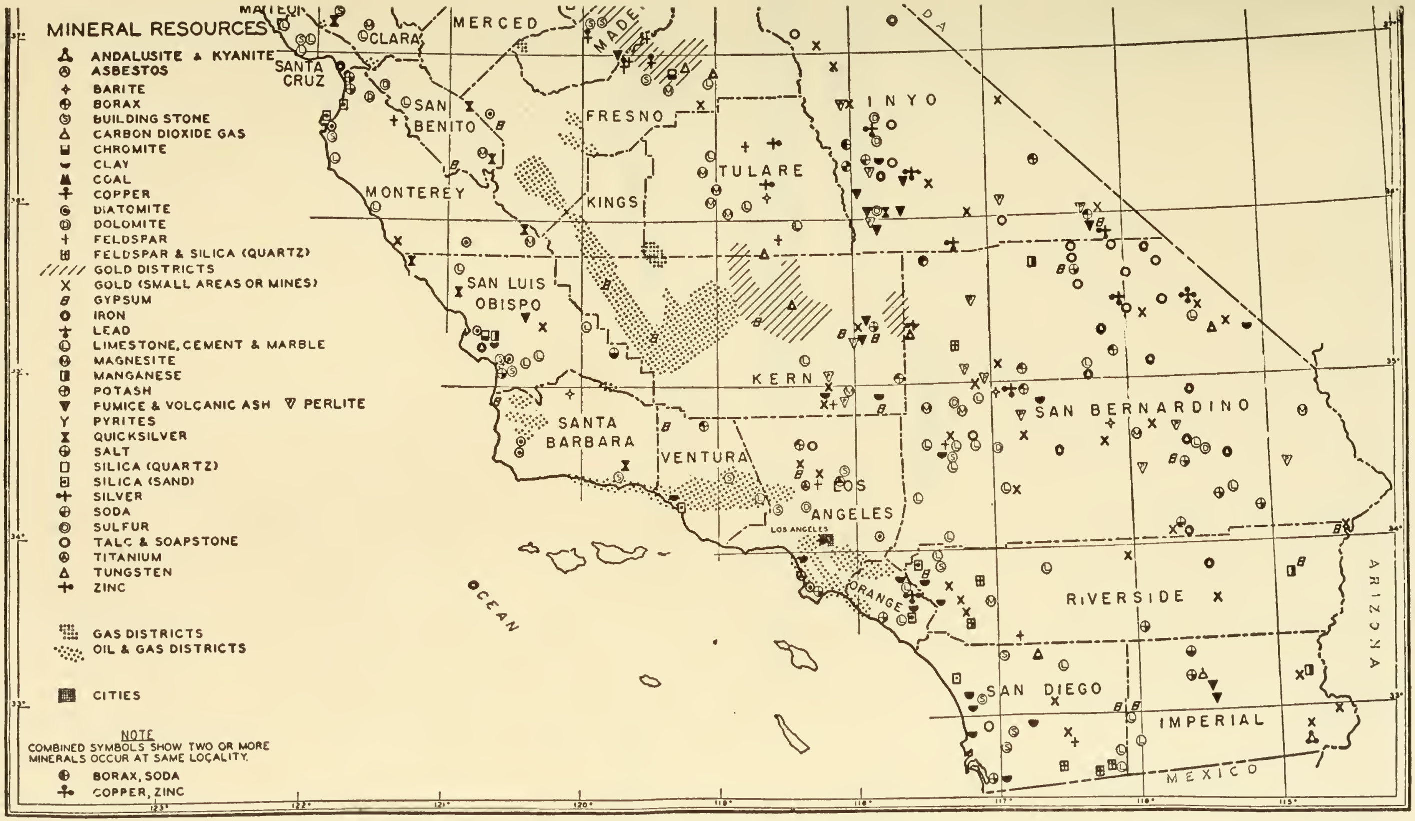

MAP OF
CALIFORNIA
SHOWING THE
DISTRIBUTION OF PRINCIPAL MINERAL RESOURCES
PREPARED BY THE
STATE DIVISION OF MINES
SCALE
16 0 16 32 48 64 MILES
1948
OREGON
NEVA
PACIFIC
DEL NORTE
SISKIYOU
MODOC
SHASTA
LASSEN
TRINITY
HUMBOLDT
TEHAMA
PLUMAS
SIERRA
NEVADA
PLACER
EL DORADO
BUTTE
YUBA
GLENN
COLUSA
SUTTER
YOLO
LAKE
MENDOCINO
SONOMA
NAPA
SOLANO
MARIN
SAN FRANCISCO
SACRAMENTO
AMADOR
ALPINE
CALAVERAS
TUOLUMNE
MONO
MARIPOSA
SAN JOAQUIN
STANISLAUS
CONTRA COSTA
ALAMEDA
SANTA
SAN
REDDING


MINERAL RESOURCES
ANDALUSITE & KYANITE
ASBESTOS
BARITE
BORAX
BUILDING STONE
CARBON DIOXIDE GAS
CHROMITE
CLAY
COAL
COPPER
DIATOMITE
DOLOMITE
FELDSPAR
FELDSPAR & SILICA (QUARTZ)
GOLD DISTRICTS
GOLD (SMALL AREAS OR MINES)
GYPSUM
IRON
LEAD
LIMESTONE, CEMENT & MARBLE
MAGNESITE
MANGANESE
POTASH
PUMICE & VOLCANIC ASH
PERLITE
PYRITES
QUICKSILVER
SALT
SILICA (QUARTZ)
SILICA (SAND)
SILVER
SODA
SULFUR
TALC & SOAPSTONE
TITANIUM
TUNGSTEN
ZINC
GAS DISTRICTS
OIL & GAS DISTRICTS
CITIES
NOTE
COMBINED SYMBOLS SHOW TWO OR MORE MINERALS OCCUR AT SAME LOCALITY.
BORAX, SODA
COPPER, ZINC
MATEO
CLARA
SANTA CRUZ
SAN BENITO
MONTEREY
MERCED
MADERA
FRESNO
KINGS
TULARE
INYO
SAN LUIS OBISPO
KERN
SANTA BARBARA
VENTURA
LOS ANGELES
ORANGE
SAN BERNARDINO
RIVERSIDE
SAN DIEGO
IMPERIAL
ARIZONA
MEXICO
OCEAN
DA
123°
122°
121°
120°
119°
118°
117°
116°
115°
37°
36°
35°
34°
33°

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PLATES

Plate 4. Geologic map of Marin County showing mines and mineral deposits — In pocket

MANGANESE DEPOSITS ON THE NORTHEAST PACIFIC SEA FLOOR[1]

ROBERT S. DIETZ *

OUTLINE OF REPORT

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ABSTRACT

Sea floor dredging by the H.M.S. *Challenger,* the U.S.S. *Albatross,* the U.S.S. *EPC(R) 857,* and vessels of the Scripps Institution of Oceanography shows that extensive deposits of manganese nodules are on the deep sea floor and that crusts of manganese dioxide cover many seamounts. Sea floor photography reveals that in some places these crusts are quite continuous and the nodules are closely packed. These crusts and nodules are fully oxidized and hydrated mixtures of manganese and iron plus earthy impurities. Also, relatively high concentrations of the trace elements nickel, copper, and cobalt are present.

INTRODUCTION

One of the many significant findings of the famous *Challenger* Expedition (1873-76) was the discovery of the abundance of black hydrous manganese dioxide on the sea floor. Subsequently other vessels, notably the U.S. Bureau of Fisheries, *Albatross,* also recovered large amounts of this substance in the Pacific, confirming the fact that extensive deposits are on the deep sea floor. Recent oceanographic work in the northeastern Pacific by vessels of the Scripps Institution of Oceanography and the U.S. Navy have provided additional information on submarine manganese deposits. The present paper is a summary of knowledge of manganese in the northeastern Pacific.

Acknowledgments. The writer is indebted to several of his colleagues at the Navy Electronics Laboratory and the Scripps Institution of Oceanography for useful ideas and information. Critical reading of the first draft of the paper by H. W. Menard, E. Goldberg, and M. N. Bramlette was especially helpful. D. F. Hewett of the U.S. Geological Survey made useful comments. The chemical analyses of table 1 were

---

* U. S. Navy Electronics Laboratory, San Diego 52, California.

[1] U. S. Navy Electronics Laboratory Professional Contribution No. 5.
Contribution from the Scripps Institution of Oceanography, New Series, No. 782.

Table 1. Chemical analyses of some manganese crusts and nodules.

Sample number	Location	N. Lat.	W. Long.	Type of sample	Mn	Fe	Co	Ni	Depth
NH-47	N.E. of Hawaii	40–14	155–05	Nodule	13.2	11.6	0.25	0.40	2,790 fms.
NH-D-1†	Gilbert Seamount	52–47	150–05	Crust	23.2	9.6	0.50	0.63	800 fms.
NH-D-7	Seamount GA-3	56–10	145–15	Crust	20.9	13.4	0.40	0.37	800 fms.
667	Erben Seamount	32–56	132–30	Crust	25.6	11.4	0.90	0.40	390 fms.
26-A-3	Seamount 19171	19–25	171–00	Nodule	22.2	13.2	0.80	0.52	740 fms.

* Analyses by H. E. Peterson, U. S. Bureau of Mines, Salt Lake City, Utah.

† A more complete analysis of sample NH-D-1 shows that, in addition to the above analysis, it contains percentages as follows: 3.1 CaO, 1.9 MgO, 8.4 SiO_2, 3.0 Al_2O_3, 0.50 P_2O_5, 0.13 V_2O_5, 0.90 TiO_2, 0.20 Mo, 0.55 S, 0.06 Cu, 11.0 insol., and 25.4 loss on ignition.

Table 2. Partial analyses of some sea floor manganese.

Location	Fe	Mn	Ni	Co	Depth (in fathoms)
N.E. of Hawaii 27°20′N	16.47	14.30	0.20	0.20	2,790
150°10′E	17.99	14.44	0.32	0.21	
	16.53	14.90	0.29	0.12	
Gilbert Seamount 52°47′N	15.07	18.52	0.30	0.25	800
150°05′W	14.78	19.95	0.31	0.31	
	14.54	19.96	0.31	0.37	
Cape Johnson Guyot 17°04′N	12.86	21.40	0.60	0.61	1,000
177°15′W	12.60	22.58	0.65	0.64	
	14.71	19.11	0.48	0.38	
N.E. Pacific 40°14′N	12.00	13.48	0.21	0.15	2,790
155°05′W	12.23	13.34	0.16	0.12	
	9.16	10.78	0.24	0.07	
Sylvania Seamount 11°57′N	17.20	18.58	0.37	0.08	750
164°46′E	15.64	15.22	0.39	0.32	
	14.50	17.62	0.38	0.24	
GA-3 Seamount 56°10′N	13.03	19.38	0.58	0.23	800
145°15′W	12.86	22.53	0.42	0.19	
	13.29	18.69	0.53	0.35	

Analyses made on three separate pieces of the same nodule.
All results are given in weight percent.

run by Goldberg and those of table 2 through the courtesy of J. Bruce Clemmer of the U.S. Bureau of Mines.

PHYSICAL PROPERTIES AND CHEMICAL COMPOSITION OF MANGANESE

Manganese dioxide, formed in the place where it now occurs, is widely distributed in deep sea sediments as grains, nodules, and coatings on rocks. This sea floor manganese is a dull, dirty brown to an earthy black; it soils the fingers, and is easily scratched by a knife. Small black manganese dioxide grains about 0.5 mm in diameter are an almost invariable constituent of red clay and a common constituent of organic deep-sea oozes. Nodules and slablike masses of manganese dioxide are also common on the deep sea floor. These have a bulbous, reniform, or potato-like shape and are less than a centimeter to as much as 20 cm in diameter, but generally are about 5 cm. Figure 1 shows the appearance of some manganese dioxide crusts and nodules. Upon splitting, they display thin concentric onionlike growth layers formed by the discontinuous accretion of manganese dioxide. The nodules commonly have a nucleus consisting of palagonite (yellow, amorphous, hydrated alteration product of basaltic volcanic glass), a basaltic fragment, pumice, a shark tooth, or a fish tooth. Generally associated with the nodules are red clay, pumice, palagonite, shark teeth, whales earbones, and small spheres thought to be of meteoritic origin. It is a matter of common observation that rocks exposed to sea water for a long time are covered with a film of manganese—the degree of burial of a rock projecting above the bottom is often indicated by such a film. In some localities these films have apparently grown into crusts several inches thick. Figure 2 shows an example of such a thick, nodular crust enclosing indurated red clay.

Sea floor manganese is an impure mixture comparable to wad or bog manganese. In addition to manganese peroxide, this amorphous and opaque substance is composed of limonite and traces of copper, cobalt, and nickel. Also sometimes included as impurities in some deposits are found in the deposits in which the nodules are imbedded such as detrital mineral grains, clay, hydrated silica, calcium carbonate, magnesium carbonate, and calcium phosphate. Manganese is generally more abundant than iron but not always. The amount of manganese dioxide (MnO_2) ranges from a few percent in some impure crusts to as much as 63 percent. Of a total of 40 analyses made of the *Challenger* collection, one contained more than 60 percent, five between 50 and 60 percent, one between 40 and 50 percent, nine between 33 and 40 percent, and 16 between 20 and 30 percent (Murray and Renard, 1891, p. 370).

Several partial analyses of manganese dioxide crusts and nodules obtained from the sea floor by vessels of the Scripps Institution of Oceanography are presented in tables 1 and 2. Four partial analyses and one complete analysis are given in table 1. Omitting the sample from the northeast of Hawaii which is apparently impure, the four other analyses show an average manganese content of 23 percent and an average iron content of 12 percent, or approximately a 2:1 manganese to iron ratio. For these four samples, cobalt has the surprisingly high maximum value of 0.80 percent and an average value of 0.65 percent, whereas nickel shows a maximum value of 0.63 percent and an average value of about 0.50 percent. Table 2 contains some partial analyses prepared by E. Goldberg of Scripps Institution of Oceanography which give results similar to those of table 1.

CHEMISTRY OF MANGANESE IN THE OCEAN

According to Rankama and Sahama, (1950, pp. 640-653) who discuss the geochemistry of manganese in considerable detail, MnO forms about 0.15 percent of gabbro and about 0.05 percent of granite. Next to titanium it is the most abundant trace element in rocks. Chemically manganese resembles iron in many respects. The ratio of iron to manganese in igneous rocks is surprisingly constant and is about 1:0.016.

The manganese content of sea water has the low value of about 0.001 to 0.01 mg/kg. (Sverdrup, et al., 1946, p. 176) Manganese is added to the ocean by streams, by submarine eruptions, and by decomposition of

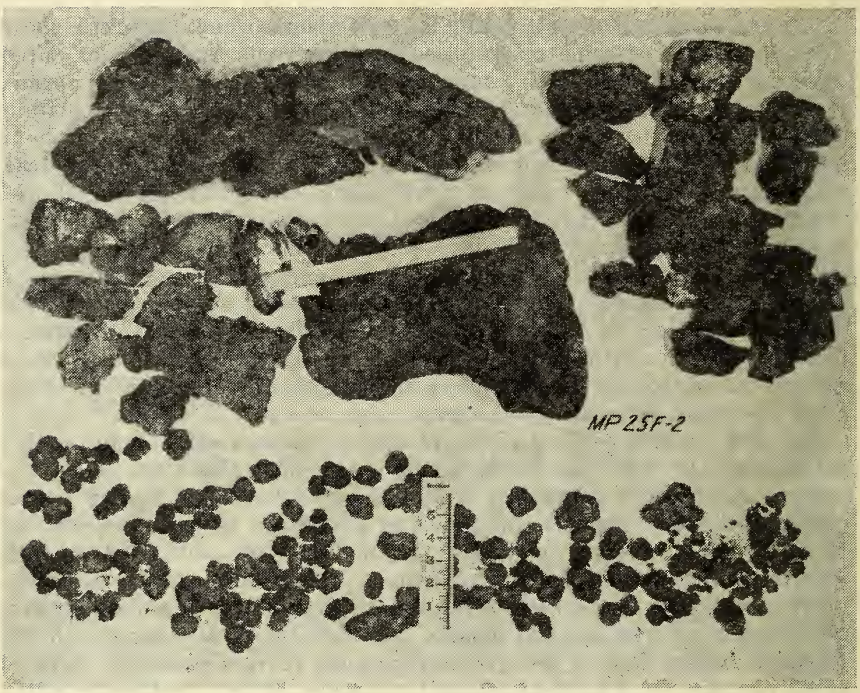

FIGURE 1. Manganese nodules and manganese-encrusted rocks recovered from a depth of 900 fathoms near the west end of Horizon Guyot (a guyot is a flat topped seamount) at Lat. 19° 05′ N. and Long. 169° 45′ W. In the upper right are broken manganese crusts; in the upper center and upper left are encrusted sandstones; and along the bottom of the photograph are small manganese nodules.

sea-floor rocks. A study of sea floor fathograms (Dietz, unpublished information) suggests that a large part of the Pacific sea floor is rough, and presumably rocky. Inasmuch as these rocks are probably largely manganese-rich basic eruptives it appears likely that submarine decomposition is an important source of manganese. Decomposition by carbonate- and sulfate-bearing seawater releases manganese mainly as the bicarbonate but probably also as manganese sulfate. Manganese compounds go into solution under conditions of acidic and low oxidation-reduction potential and are precipitated under conditions of high oxidation-reduction potential and alkaline conditions such as exist in the red clay. In the presence of the dissolved oxygen in the sea, the bicarbonate is quickly transformed to colloidal hydroxide which may be stabilized by organic compounds. Under proper conditions, as in the water immediately surrounding a manganese nodule or crust, manganese is precipitated as $MnOH$ or hydrated MnO_2. The hydrated MnO_2 rapidly loses its water of crystallization and the water found associated with deep sea nodules is adsorbed water. The botryoidal and cryptocrystalline form of the nodules shows that precipitation took place from colloidal particles rather than from ions in solution.

Unusual concentrations of certain trace elements such as cobalt and nickel are found in manganous nodules. As noted above, nickel, attains concentrations as large as 0.65 percent and cobalt nearly 1 percent. These concentrations appear to depend on the manganese content and to be independent of the iron content. Both nickel and cobalt have a concentration in sea water which is far below their saturation value so that they must be selectively removed from the ocean. Goldberg (personal communication) has concluded, therefore, that these metallic positively charged ions are carried down by the negatively charged colloidal manganese hydroxide by a process of adsorption or ''scavenging.''

Manganese is an essential element to both plants and animals. Many aqueous plants are able to accumulate manganese as $Mn(OH)_4$ and manganese plays a role in the reduction of nitrates both in green plants and in green algae. Manganese can be precipitated by the removal of carbon dioxide from the bicarbonate by bacterial action or by direct oxidation. It is unknown whether or not organisms have an essential role in the formation of manganese deposits on the sea floor.

RATE OF ACCUMULATION

The rate of growth of manganese dioxide nodules has been studied by Pettersson (1943) using a radioactivity method. He concluded that the rate of growth of the two nodules examined was of the order of 1 mm per 1,000 years. But inasmuch as the rate of supply of manganese might vary over wide limits in different localities, this rate of accumulation cannot be generally applied. For example, it is possible that the manganiferous solutions forming the deposits are largely of local origin, being derived from the decomposition of volcanic rocks extruded on the sea floor in the immediate vicinity of the manganese deposits. This decomposition would proceed rapidly after the flows were first extruded, but would cease as soon as hydrothermal activity and decomposition of the upper few feet was complete. Rapid deposition of manganese compounds would take place only as long as weathering continued. Nevertheless, there is no question but that thick coatings of manganese indicate a long period of exposure to sea water. Off California, manganese dioxide films are not found on rocks of the shelf or of shallow banks shallower than about 65 fms. Such surfaces appear to have been exposed recently to surf action—presumably during the last Pleistocene lowering of sea level approximately 20,000 years ago. Subsequently there has been insufficient time for the accumulation of manganese. Rocks dredged by Menard (personal communication) from the tops of seamounts in the Gulf of Alaska showed that the basaltic country rock is commonly thickly encrusted with manganese dioxide but that erratic continental rocks presumably rafted onto the seamount by Pleistocene icebergs have, at most, a thin coating. This indicates that the accumulation of manganese is a slow process.

Erben and Fieberling Guyots (seamounts) present an interesting situation in regard to the accumulation of manganese (Carsola and Dietz, 1952). Although these banks are geographically close and appear to offer similar physical-chemical environments, a thick crust of manganese dioxide was found covering the rock dredged from Erben Guyot but only a thin coating was found at Fieberling Guyot. This is possibly because the surface of the latter guyot is younger, but it is also possible that the sampling was not representative. Fossil evidence shows that the Erben Guyot surface was cut before the middle Miocene. The age of the Fieberling surface is not known.

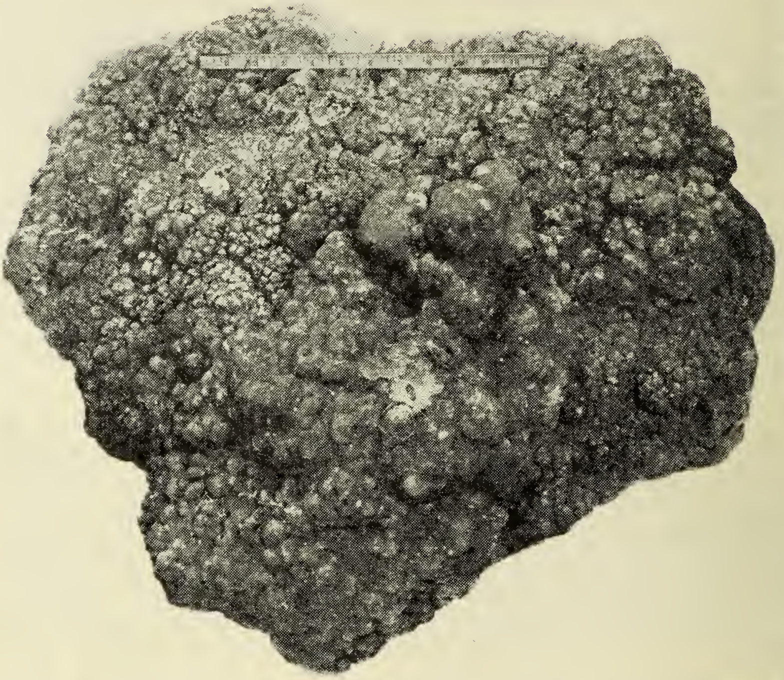

FIGURE 2. This large nodular mass of manganese (25 inches long, 21 inches wide, and 13 inches high) was recovered from 2790 fathoms at Northern Holiday Station 47 several hundred miles northeast of Hawaii (Lat. 40° 14′ N; Long. 155° 05′ W). This is probably the largest nodule of manganese ever recovered from the sea floor. Sectioning of the nodule showed the center to consist of an indurated layer of whitish red clay.

Thick crusts of manganese dioxide are found covering the 100,000,000-year-old mid-Cretaceous surfaces of the guyots of the Mid-Pacific Mountains (Hamilton, 1952). These crusts are of the order of several inches thick, instead of the 100 meters to be expected if a growth rate of 1 mm/1000 years is applied. Presumably either the rate of accumulation there is less than Pettersson's figure or the guyot surface has been affected by processes that would stop manganese accretion.

In summary, it appears that thick accumulations of manganese compounds probably form only on surfaces which have been exposed to oxidizing sea water for a long period of time. Environments unfavorable to the accumlation of manganese are those where sediments are being deposited, where the rocks are too recently emplaced to be weathered, or where the sea floor has been exposed to surf action of the Pleistocene lowered sea levels such as the continental shelves and the tops of shoal seamounts.

DISTRIBUTION OF MANGANESE IN THE NORTHEAST PACIFIC

Inasmuch as corers and grab samplers rarely recover rock, dredging is the only method likely to yield much information on the presence of manganese. It is not surprising then, that most information regarding manganese deposits in the Pacific has come from the *Challenger,* the *Albatross,* and vessels of the Scripps Institution, all of which have done extensive dredging.

No data are available on the percentage of manganese in bottom sediments of the Pacific, but Malloy (unpublished manuscript), by a study of the published descriptions of 1426 bottom samples taken in the Atlantic, found manganese in almost half of the red clay samples but in less than 10 percent of the globigerina ooze and blue mud samples. Inasmuch as the northeast Pacific is largely a red clay province, manganese may be expected to be common. Table 3 is adapted from Malloy's study. It shows the distribution of manganese grains, coatings, or nodules with respect to bottom type.

Occurrence in the Open Pacific. The *Challenger* reported (Murray and Renard, 1891, pp. 341-378) that ferruginous manganese nodules are among the most widely distributed objects in marine sediments, being especially characteristic of the abyssal Pacific red clays. The stations

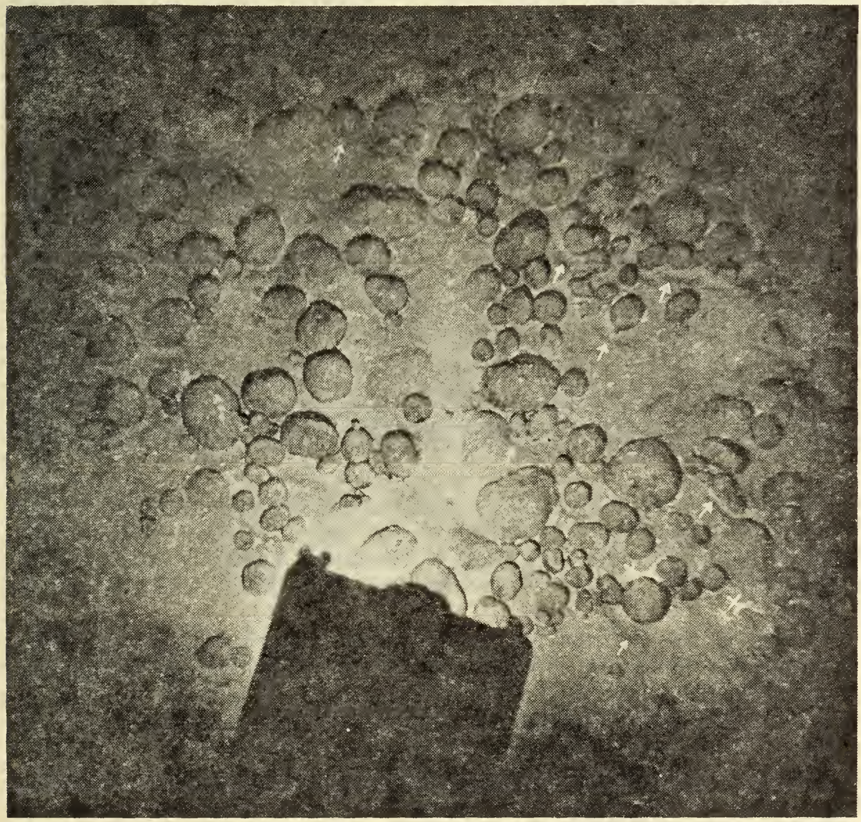

Figure 3. Deepest underwater photograph ever taken (3026 fathoms) showing a cluster of objects, some as much as 5 inches across on a red clay bottom. These appear to be manganese nodules, judging from their rounded and bulbous shape—note especially the potato-like form of some of them. A core sample obtained at the same spot with a corer attached to the camera stand contained abundant manganese grains. Field of view is 6 feet. Location is about 300 miles southeast of Bermuda (Lat. 30° 37′ N, Long. 59° 07′ W). Of additional interest is the evidence of current action at this great depth as indicated by (a) lack of sediment on top of the nodules; (b) scours in front of the objects, some of which are marked with an arrow; and (c) deposition of white material, presumably Globigerina ooze, in the lee of certain nodules as at the point marked "x". Some persons will find this photograph more intelligible if turned upside down so that the shadows fall toward the reader. *Photograph taken with an Ewing-Worzel camera by David Owen, Woods Hole Oceanographic Institute.*

Table 3. Distribution of manganese dioxide with respect to sediment type in the Atlantic.

Type of deposit	Number of samples	Mean depth (in fathoms)	Number of samples containing manganese dioxide	Percent of samples containing manganese dioxide
Globigerina ooze	772	1975	43	6
Blue mud	342	1268	12	4
Red clay	126	2957	54	43
Volcanic mud and sand	102	821	1	1
Pteropod ooze	40	1133	6	15
Green mud and sand	17	494	0	0
Coral mud and sand	9	1119	0	0
Diatom ooze	8	2106	0	0
Red mud	8	641	0	0
Calcareous sand	2	424	0	0

where the *Challenger* recovered large amounts of manganese in the north central and northeast Pacific are shown in figure 5. The haul at Station 252 is typical of one of their larger hauls of the nodules. Murray and Renard (1891, pp. 352-354) report:

> . . . The trawl brought up many hundreds of manganese nodules . . . .; there was no clay mixed with these nodules, having apparently been all washed away as the trawl was hauled up through the water. The largest nodules were about the size of cricket balls; they were more or less round or ellipsoidal, and when rolled on the deck they looked like a pile of dirty potatoes. . . . On the fracture of these nodules by a blow, they separated into large concentric scales.

Three stations where the *Albatross* dredged large amount of manganese are also indicated in figure 5. *Albatross* Station 2 is of special interest because of its proximity to California and because 800 pounds of nodules were dredged up at that locality (Agassiz, 1902, pp. 70-72), which is probably the largest haul from any single spot. There were also a number of slabs of rock with manganese crusts as much as 6 inches thick. At Station 13 the *Albatross* recovered another trawl full of manganese nodules ranging in diameter from 4½ to 6 inches. Off northern South America (in the region only partially covered by the lower righthand corner of figure 5) the *Albatross* recovered nodules from so many stations that Agassiz concluded that a region with an area greater than the U. S. was virtually blanketed with manganese dioxide.

Vessels of the Scripps Institution of Oceanography and the Navy Electronics Laboratory have added to our knowledge of manganese deposits by dredging on the top of seamounts. This work has demonstrated that crusts of manganese compounds several inches thick coat the tops of the seamounts. The locations of some of the most heavily encrusted seamounts are shown in figure 5. Dredge hauls from Erben Guyot and nearby Fieblering Guyot have been described by Carsola and Dietz (1952). Several manganese-encrusted guyots in the Mid-Pacific Mountains region west of the Hawaiian Islands were dredged during the Scripps-Navy Mid-Pacific Expedition, 1950. These have been described by Hamilton (1952). Dredging the Gulf of Alaska by the Scripps vessel *Horizon* revealed the presence of thick crusts of manganese dioxide on Gilbert and Miller Guyots. Returning from the Gulf of Alaska the *Horizon* recovered a large concretionary mass of manganese dioxide north of Hawaii. This 25 x 21 x 13-inch mass was

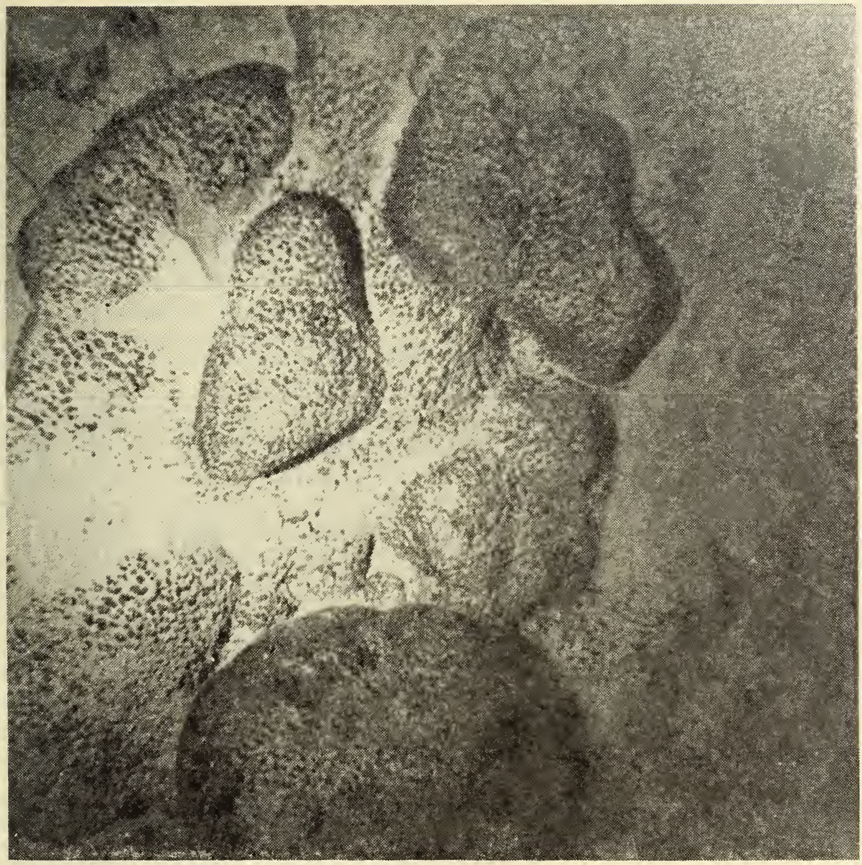

FIGURE 4. Sea floor photograph taken at a depth of 4,500 feet (750 fathoms) showing a portion of the top of Sylvania Guyot near Bikini Atoll. Rocks shown compare closely with one dredged nearby and thus are probably basalt boulders thickly encrusted with manganese. The asperities on the surface are characteristic of the manganese from this seamount. White, rippled, globigerina ooze lies between the rocks. *Photograph taken by C. J. Shipek, H. W. Menard, and the writer with a special camera developed at the Navy Electronics Laboratory. Official U. S. Navy photograph.*

snagged by excess wire rope laid on the bottom after a core had been taken. It is believed to be the largest mass of manganese dioxide ever recovered from the sea floor. Oceanographic dredges normally have an opening too small to accommodate an object of this large size.

Occurrence off Southern California. Emery and Shepard (1945, pp. 431-478) dredged rock from 132 localities in the continental borderland off southern California in 1938. They (p. 461) reported manganese dioxide cementing andesite fragments from the top of a seahill (32-16N and 117-32W; 385 fms) about 30 miles southwest of San Diego. The present writer took part in these dredgings and he recalls that a considerable quantity of manganese crusts was recovered from this locality. Also dredging from San Juan Seamount (Lat. 33° 06′ N. and Long. 120° 58′ W.) just beyond the continental slope yielded chips of manganese along with chips of basalt. A core taken near the base of this seamount recovered small fragments of manganese. It is likely

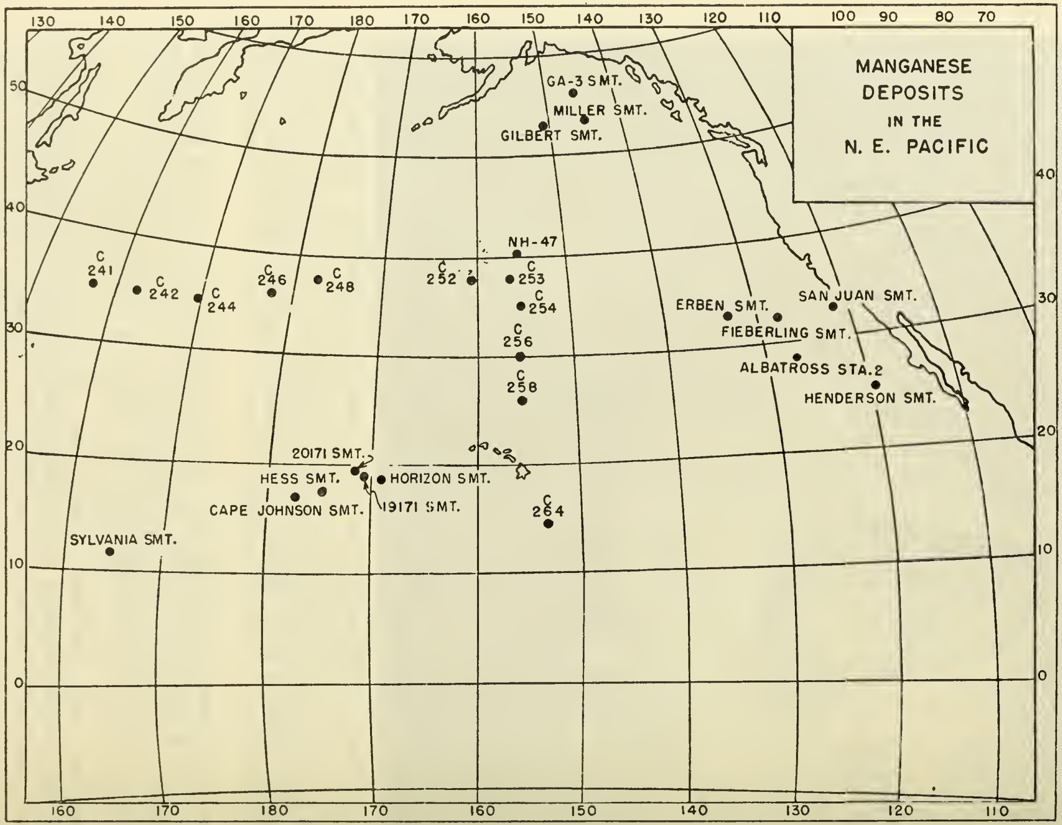
MANGANESE
DEPOSITS
IN THE
N. E. PACIFIC
GA-3 SMT.
MILLER SMT.
GILBERT SMT.
NH-47
C 241
C 242
C 244
C 246
C 248
C 252
C 253
C 254
C 256
C 258
C 264
ERBEN SMT.
SAN JUAN SMT.
FIEBERLING SMT.
ALBATROSS STA.2
HENDERSON SMT.
20171 SMT.
HESS SMT.
HORIZON SMT.
CAPE JOHNSON SMT.
19171 SMT.
SYLVANIA SMT.
130
140
150
160
170
180
170
160
150
140
130
120
110
100
90
80
70
50
40
30
20
10
0

FIGURE 5. Chart of the northeast Pacific showing locations where large amounts of manganese have been dredged. Those marked with a "C" are *Challenger* stations. *Albatross* Station 2 marks the position of a large dredge haul of manganese nodules obtained by the U. S. Bureau of Fisheries vessel *Albatross*. The manganese from Erben, Fieberling, and Henderson Seamounts was dredged by the Navy patrol craft *EPCE(R) 857*. The rest of the deposits are based on dredge hauls by vessels of the Scripps Institution of Oceanography.

that sampling with suitable dredges would show that this seamount is encrusted with a considerable amount of manganese dioxide.

Dietz, Emery, and Shepard (1942) and Emery and Dietz (1950), have reported on the large amounts of phosphorite recovered in connection with these dredging operations from the research vessel *E. W. Scripps.* These phosphorite nodules are typically coated with films of manganese dioxide and manganese compounds are found as partings in the interior of them. Presumably, manganese was deposited during periods of nondeposition of the phosphorite. However, the near-shore areas appear to be unfavorable environments for the deposition of large amounts of manganese.

QUANTITY OF MANGANESE ON THE SEA FLOOR AS INDICATED BY SEA FLOOR PHOTOGRAPHY

Dredging gives little information regarding the abundance of manganese on the sea floor. Although a dredge may come up filled with manganese nodules, the distance over which the dredge has been towed is always poorly known. Also, the sampling selectively and efficiency of sea floor dredges is unknown. Another complicating factor is that dredges commonly spill their loads. Thus, although a dredge may come up filled with manganese nodules, there is no proof that these objects are concentrated rather than widely dispersed over the bottom. Fortunately a visual assessment of the bottom can be obtained by photography. Although this technique is still experimental, important information on sea floor mineral deposits has already been obtained. By bottom photography Emery and Dietz (1950) demonstrated that the phosphorite deposits on the banks off southern California form continuous nodular beds covering many tens of square miles. More recently photographs have been obtained which demonstrate that manganese also is in concentrated deposits. Two such photographs are reproduced in figures 3 and 4.

Figure 3 is a sea floor photograph taken in the Atlantic near Bermuda at 3026 fathoms (18,156 feet). The objects shown are almost certainly manganese nodules. More than 200 nodules are shown. This photograph is one of the few ever taken of the deep sea floor. The fact that it shows these nodules suggests that they are common on the sea floor. Such a photograph clearly demonstrates that the nodules are present in great concentration rather than being widely dispersed over the bottom.

Figure 4 shows rocks with thick encrustations of manganese judging by the similarity of the objects in the photograph with some manganese-encrusted basalt dredged nearby. Such rugose surfaces commonly develop on manganese encrustations. The photograph was taken at a depth of 750 fathoms on the top of Sylvania Seamount near Bikini atoll.

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MINES, MINERAL RESOURCES, AND MINERAL INDUSTRIES OF MARIN COUNTY, CALIFORNIA

BY WILLIAM E. VER PLANCK *

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* Geologist, California State Division of Mines.

ABSTRACT

Marin County, one of the original 27 counties of California organized in 1850, lies immediately north of the Golden Gate between the Pacific Ocean and San Francisco and San Pablo Bays. Except for the Point Reyes Peninsula the county is a dissected mountain mass of high relief that culminates in Mount Tamalpais, a conspicuous landmark in the San Francisco area. The Point Reyes Peninsula, a triangular area lying west of Tomales Bay and Bolinas Lagoon, is of comparatively subdued topography.

The San Andreas fault, which passes through Tomales Bay and Bolinas Lagoon, divides Marin County into two structural blocks of different geology, the San Francisco-Marin block to the east and the Montara block to the west. In the San Francisco-Marin block the dominant formation is the Jurassic (?) Franciscan group, including greenstone and serpentine. The Cretaceous (?) Novato conglomerate, which occupies a 3 square mile area northeast of Novato, rests on serpentine. Unconformably overlying the Franciscan group are the Pliocene Sonoma volcanics north of Novato and the marine Merced formation, also Pliocene, along the north edge of the county. On the Point Reyes Peninsula folded Miocene marine sediments lie on a basement of quartz diorite which contains small, isolated roof pendants of limestone, schist, and quartzite.

Although Marin is one of the smallest counties of California it ranked 22nd in population in 1940. The principal industries in order of their importance are agriculture, light manufacturing, and mining. In 1953 clay, crushed and broken stone, and sand and gravel valued at $1,041,683 were produced. Aggregates and jetty stone are produced from hard "blue" sandstone members of the Franciscan group by the Basalt Rock Company at McNear Point and by the Hutchinson Company at Greenbrae. Aggregates also are produced by Black Point Aggregates Incorporated from the Novato conglomerate at Black Point, by the Marin Gravel Company from the Sonoma volcanics north of Novato, and by Joslin Brothers from stream gravel near Point Reyes Station. At McNear Point the McNear Brick Company produces the lightweight aggregate Haydite and the L. P. McNear Brick Company common brick from shale of the Franciscan group. A deposit of scheelite associated with Paleozoic(?) limestone and quartz diorite is under development near Inverness, and wells have been drilled for petroleum on the Point Reyes Peninsula. During World War II manganese was produced from the Knutte deposit near Novato, and a deposit of cinnabar east of Marshall was explored. At various times in the past paving blocks, dimension stone, mineral water, copper, salt, jasper, and lime have been produced; and deposits of nephrite, coal, gold, and silver have been explored.

Marin County's small but diversified manufacturing industry is centered in San Rafael and Marinship. A gunite contractor uses concrete sand and Haydite as aggregates. A distillery and a manufacturer of inorganic chemicals employ diatomite as filter aids. Fire clay and expanded vermiculite are consumed in the manufacture of lightweight refractories. Manufacturers of pottery products consume clays, pottery plaster, and glaze materials. Pumice and Haydite are used as aggregates in lightweight concrete blocks and colored aggregates for terrazzo. A company manufactures traffic guides from casting plaster and fillers, and raw sized perlite is expanded into lightweight aggregates by another company. Foundry sands are consumed by a gray iron foundry, and silica sand is used by monument shops for sandblasting.

INTRODUCTION

Marin County lies just north of the Golden Gate, and its southern half forms a peninsula between the Pacific Ocean on the west and San Francisco and San Pablo Bays on the east. Of the islands in San Francisco Bay, the Marin Islands and most of Angel Island are included within the county; but Alcatraz Island and Red Rock are not. A small portion of Angel Island including the idle Fort MacDowell quarry is in the City and County of San Francisco. Sonoma is the county adjoining on the north; and the boundary between them follows Petaluma Creek and San Antonio Creek to Chileno Valley, thence northwestward to Estero Americano and along that stream to Bodega Bay on the ocean coast.

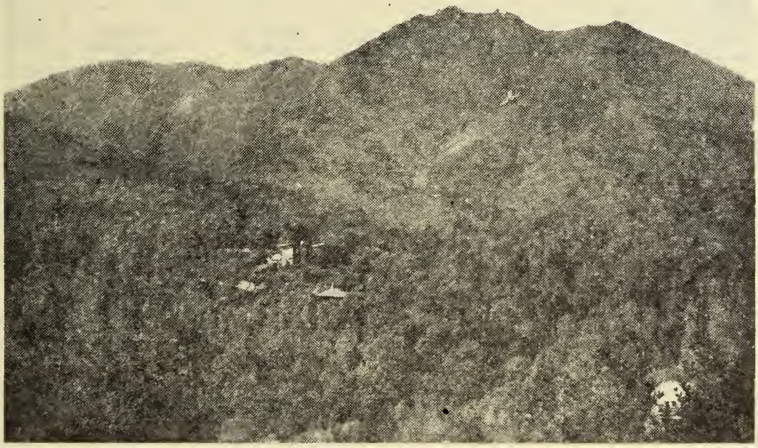

FIGURE 1. East side of Mount Tamalpais. *Photo by Mary R. Hill.*

With a land area of 333,440 acres, Marin is one of the smallest counties of California, but on the basis of the 1940 census it ranks 22nd in population. About half of the wages and salary income is received by commuters who work outside the county. Marin County ranks 33rd in value of mineral production.

Topography. With the exception of the Point Reyes Peninsula, Marin County forms the southern extension of the Mendocino Range. The area is a mountain mass of high relief that has been dissected by erosion. Mount Tamalpais, elevation 2604 feet, is the highest point in the county and a conspicuous landmark in the San Francisco area. As in other sections of the Coast Ranges the principal topographic and structural features trend northwestward. The Golden Gate is a gorge cut through the range by the Sacramento River at a time when the sea stood at a lower elevation relative to the land than it does today (Louderback, 1951). To the north the range is interrupted by a dissected plateau of comparatively low relief and elevation. Most of this plateau lies in Sonoma County between Santa Rosa Valley and the ocean, but the south margin is in Marin County.

Mount Tamalpais, a wall-like ridge that extends northeastward across the southern portion of Marin County, is dissected by steep gorges; and sharp backed ridges diverge from the summit. The Marin Peninsula is formed by such a ridge that trends southeastward toward the Golden Gate. Within a mile of Lime Point elevations on the ridge crest are nearly 1000 feet. Other southeastward- and eastward-trending ridges that extend into San Francisco Bay form the Tiburon Peninsula and Angel Island, Point San Quentin, McNear Point, and Black Point. The valleys that lie between head far into the interior of the mountain mass, and their drowned lower reaches are filled with salt marshes and alluvium.

Mineral production of

Year	Clay			Mineral water		Stone products							
						Crushed and broken stone							
	Brick		Pottery clay[2]	Gallons	Value	Road stone and ballast[3]		Rubble and rip rap[4]		Concrete aggregate[5]		Unclassified[6]	
	M	Value				Tons	Value	Tons	Value	Tons	Value	Tons	Value
1888	1,600	$10,000	----	----	----	----	----	----	----	----	----	----	----
1889	[8]2,000	12,000	----	----	----	----	----	----	----	----	----	----	----
1890	[8]5,000	30,000	----	----	----	----	----	----		----	----	----	----
1891	[8]10,000	60,000	----	----	----	----	----	----	----	----	----	----	----
1892	[8]12,000	72,000	----	----	----	----	----	----	----	----	----	----	----
1893	18,000	108,000	----	----	----	----	----	----	----	----	----	----	----
1894	28,500	172,500	----	----	----	6,250	$8,750	2,800	$5,000	----	----	----	----
1895	29,000	145,000	----	----	----	3,162	3,860	----	----	----	----	----	----
1896	15,000	85,000	----	----	----	6,119	6,530	1,730	1,730	----	----	----	----
1897	15,000	89,000	----	----	----	6,000	7,200	----	----	----	----	----	----
1898	15,500	66,000	----	----	----	1,400	1,400	310	400	----	----	----	----
1899	16,500	76,000	----	----	----	1,400	1,400	3,000	3,750	----	----	----	----
1900	25,000	200,000	----	----	----	----	----	3,000	2,500	----	----	----	----
1901	14,320	100,240	----	----	----	550	825	33,450	27,162	----	----	----	----
1902	14,600	97,700	----	----	----	2,150	2,150	147,350	105,350	----	----	----	----
1903	13,819	78,095	----	----	----	600	900	144,115	139,432	----	----	----	----
1904	20,500	132,000	----	----	----	----	----	216,576	170,995	----	----	----	----
1905	22,877	163,585	----	----	----	93,000	32,250	20,000	12,000	----	----	----	----
1906	23,900	199,300	----	----	----	----	----	54,000	53,000	----	----	----	----
1907	16,000	118,000	----	----	----	----	----	157,100	134,111	----	----	----	----
1908	10,000	50,000	----	52,000	$12,050	----	----	111,686	66,700	----	----	----	----
1909	4,500	105,000	----	47,500	5,075	10	10	132,000	67,000	----	----	----	----
1910	22,497	99,185	----	100,000	10,000	----	----	112,000	74,700	----	----	----	----
1911	19,695	87,445	----	328,740	36,500	----	----	145,421	90,161	[10]	----	28,225	18,625
1912	18,000	88,200	----	260,000	31,000	600	400	----	----	3,500	2,000	----	----
1913	16,000	70,500	----	60,000	9,000	----	----	421,032	193,400	225	203	7,000	5,250
1914	15,000	55,000	----	60,000	9,000	168,111	44,000	[13]731,473	365,737	10,600	5,300	150,000	75,000
1915	10,000	50,000	----	60,000	9,000	[15]40,181	10,000	[14]119,034	56,887	38,071	26,228	13,900	6,950
1916	*	----	----	*	----	[16]5,000	2,000	40,697	24,661	117,189	77,395	----	----
1917	*	----	----	*	----	200	200	106,272	72,386	201,832	83,606	300	150
1918	*	----	----	*	----	----	----	1,928	1,708	*	----	*	----
1919	*	----	----	*	----	----	----	7,673	7,887	*	----	----	----
1920	*	----	----	*	----	----	----	14,354	20,528	*	----	----	----
1921	*	----	----	*	----	----	----	----	----	----	----	----	----
1922	*	----	----	*	----	*	----	*	----	----	----	----	----
1923	*	----	*[18]	*	----	150,452	145,552	*	----	----	----	----	----
1924	*	----	*[18]	*	----	----	----	*	----	*	----	----	----
1925	*	----	*[18]	*	----	----	----	9,185	11,940	----	----	236,680	228,964
1926	*	----	----	*	----	----	----	*	----	*	----	*	----
1927	*	----	----	*	----	15,000	30,000	93,460	121,498	----	----	191,127	229,758
1928	*	----	----	*	----	13,666	20,000	*	----	----	----	*	----
1929	*	----	----	*	----	----	----	*	----	*	----	*	----
1930	*	----	----	*	----	----	----	*	----	*	----	*	----
1931	*	----	----	----	----	----	----	*	----	*	----	*	----
1932	*	----	----	*	----	*	----	----	----	*	----	----	----
1933	*	----	----	*	----	10,811	9,929	15,685	14,785	----	----	145,739	144,592
1934	*	----	----	*	----	*	----	45,752	60,044	48,807	47,807	*	----
1935	*	----	----	*	----	*	----	*	----	*	----	*	----
1936	*	----	----	*	----	*	----	*	----	*	----	*	----
1937	----	----	*[19]	*	----	54,945	67,773	41,025	49,231	*	----	184,129	138,129
1938	----	----	*[19]	*	----	*	----	*	----	*	----	*	----
1939	----	----	*[19]	*	----	37,844	34,410	*	----	*	----	*	----

Marin County, 1888-1953.

Sand and gravel[7]		Total value	Miscellaneous and unsegregated		Value of total mineral production for the year	Year
Tons	Value		Substance	Value		
--------	--------	--------	--------	--------	$10,000	1888
--------	--------	--------	--------	--------	12,000	1889
--------	--------	--------	--------	--------	30,000	1890
--------	--------	--------	--------	--------	60,000	1891
--------	--------	--------	--------	--------	72,000	1892
--------	--------	--------	--------	--------	108,000	1893
--------	--------	$13,750	Paving blocks, 100M	$3,100	189,350	1894
--------	--------	3,860	Paving blocks, 166M; dimension stone, 7000 cubic feet	$3,930;$5,000	157,790	1895
--------	--------	8,260	--------	--------	93,260	1896
--------	--------	7,200	--------	--------	96,200	1897
--------	--------	1,800	--------	--------	67,800	1898
--------	--------	5,150	--------	--------	81,150	1899
--------	--------	2,500	[9]	--------	202,500	1900
--------	--------	27,987	[9]	--------	128,067	1901
--------	--------	107,500	[9]Salt, 700 tons	1,400	206,600	1902
--------	--------	140,332	[9]	--------	218,427	1903
--------	--------	170,995	[9]	--------	302,995	1904
--------	--------	44,250	[9]	--------	207,835	1905
--------	--------	53,000	[9]Salt, 150 tons	300	252,600	1906
--------	--------	134,111	[9]	--------	252,111	1907
--------	--------	66,700	--------	--------	128,750	1908
--------	--------	67,010	--------	--------	177,085	1909
[11]	--------	74,700	--------	--------	183,885	1910
--------		108,786	--------	--------	232,731	1911
1,200	$600	[12]3,000	--------	--------	122,200	1912
100	100	198,953	--------	--------	278,453	1913
300	100	490,137	--------	--------	554,137	1914
5,850	1,463	101,528	--------	--------	160,528	1915
1,000	250	104,306	Brick, mineral water	74,000	178,306	1916
5,733	2,240	158,582	Brick, mineral water	113,720	272,302	1917
1,900	390	89,458	Brick, copper, gold, mineral water, silver	86,725	176,183	1918
28,667	14,333	127,111	Brick, mineral water	101,863	228,974	1919
43,494	18,709	208,302	Brick, mineral water	127,443	355,745	1920
--------	--------	202,333	Brick, mineral water	116,443	318,776	1921
--------	--------	*	Brick, mineral water, potash[17], crushed and broken stone	403,099	403,099	1922
*	--------	516,936	Brick, pottery clay, mineral water	171,945	688,881	1923
*	--------	356,035	Brick, pottery clay, mineral water	171,196	527,231	1924
*	--------	244,602	Brick, pottery clay, mineral water	190,200	434,802	1925
*	--------	413,712	Brick, mineral water	113,841	527,553	1926
--------	--------	381,256	Brick, mineral water	145,748	527,004	1927
13,333	20,000	309,218	Brick, mineral water	140,350	449,568	1928
--------	--------	*	Brick, mineral water, crushed and broken stone	470,002	470,002	1929
*	--------	*	Brick, mineral water, crushed and broken stone	405,541	405,541	1930
*	--------	*	Brick, crushed and broken stone, sand and gravel	544,760	544,760	1931
3,600	1,200	189,937	Brick, mineral water	63,900	253,837	1932
--------	--------	*	Brick, pottery clay, mineral water, crushed and broken stone	205,150	205,150	1933
11,300	3,750	136,127	Brick, mineral water	47,227	183,354	1934
15,600	4,775	98,663	Brick, jasper, mineral water	15,251	113,914	1935
*	--------	*	Brick, mineral water, crushed and broken stone, sand and gravel	222,974	222,974	1936
*	--------	296,844	Pottery clay, mineral water	3,600	300,444	1937
18,450	18,450	*	Pottery clay, mineral water, crushed and broken stone, sand and gravel	189,843	189,843	1938
36,718	13,222	120,256	Pottery clay, mineral water	13,500	143,756	1939

Mineral production of

Year	Clay			Mineral water		Stone products							
	Brick		Pottery clay[2]	Gallons	Value	Crushed and broken stone							
						Road stone and ballast[3]		Rubble and rip rap[4]		Concrete aggregate[5]		Unclassified[6]	
	M	Value				Tons	Value	Tons	Value	Tons	Value	Tons	Value
1940	--------	--------	----	*	--------	56,983	$56,983	11,682	$12,531	*	-------	--------	--------
1941	--------	--------	*[19]	*	--------	*	-------	*	--------	*	-------	*	--------
1942	--------	--------	*[19]	*	--------	*	-------	*	--------	*	-------	--------	--------
1943	--------	--------	*[19]	*	--------	*	-------	*	--------	--------	-------	*	--------
1944	--------	--------	*[19]	*	--------	*	-------	*	--------	--------	-------	*	--------
1945	--------	--------	*[19]	*	--------	*	-------	*	--------	*	-------	*	--------
1946	--------	--------	*[19]	*	--------	*	-------	*	--------	--------	-------	*	--------
1947[20]	[22]	--------	*[22]	[21]	--------	[23]	-------	[23]	--------	[23]	-------	*	--------
1948	--------	--------	*	--------	--------	[23]	-------	[23]	--------	[23]	-------	*	--------
1949	--------	--------	*	--------	--------	[23]	-------	[23]	--------	[23]	-------	*	--------
1950	--------	--------	*	--------	--------	;	-------	[23]	--------	[23]	-------	*	--------
1951	--------	--------	*	--------	--------	[23]	-------	[23]	--------	[23]	-------	*	--------
1952	--------	--------	*	--------	--------	[24]	-------	[24]	--------	[24]	-------	*	--------
1953	--------	--------	*	--------	--------	[24]	-------	[24]	--------	[24]	-------	*	--------

* Not disclosed; see miscellaneous and unsegregated.

[1] Stone products: Equivalent of "miscellaneous stone" as used in other tabulations of the Division of Mines.

[2] Pottery clay: Pottery clay includes clays used for all purposes except brick and hollow tile, bentonite and fuller's earth.

[3] Road stone and ballast: Equivalent of "macadam and ballast" as used in other tabulations for the Division of Mines. Road stone and ballast is angular, sized, crushed stone for base courses, waterbound macadam, bituminous macadam, and bituminous concrete as well as for railroad ballast.

[4] Rubble and riprap: Most of the material included here is coarse broken stone used for the construction of sea walls, jetties, and levees. In the pre-World War I years it includes some rough dimension stone used for walls and foundations.

[5] Concrete aggregate: Sized, angular crushed stone similar to road stone and ballast but of more exacting specifications. In this table it does not include sand and gravel used for concrete aggregate.

[6] Unclassified: Includes stone not classified by the producer as well as grades other than rubble and riprap, road stone and ballast, and concrete aggregate.

[7] Sand and gravel: Unconsolidated granular material in the 200 mesh- 3½ inch range.

[8] Brick (1889-1892, incl.): Estimated.

[9] Unsegregated, 900-07: Value of $42,000 for 1900-07 (Bull. 53), 1900-08 (Bull. 56), 1900-09 (Bull. 60), included in county grand total.

[10] Concrete aggregate: Included with "rubble and riprap" 1911 and earlier.

On the west side of the county is the Point Reyes Peninsula, a triangular mass that lies west of the San Andreas rift valley, the drowned portions of which are Tomales Bay and Bolinas Lagoon. In this section of the county both the topography and geology differ notably from that of the remainder of the county. The Point Reyes Peninsula forms the ocean shore from Bolinas nearly to the north boundary of the county.

Bordering the rift valley of the San Andreas on the northeast is Bolinas Ridge, which extends from the vicinity of Mount Tamalpais to the mouth of Tomales Bay. The highest point is Black Mountain, 1276 feet. Between Bolinas Ridge and the Bay shore of the county the land has been incised by deeply entrenched, meandering streams whose ramifying tributaries have in many places worked headward past one another. Lagunitas Creek and Walker Creek have cut through Bolinas Ridge and drain large sections in the interior of the county. The divide

Marin County, 1888-1953—Continued

			Miscellaneous and unsegregated		Value of total mineral production for the year	Year
Sand and gravel[7]		Total value	Substance	Value		
Tons	Value					
*	--------	*	Mineral water, crushed and broken stone, sand and gravel	$151,800	$151,800	1940
*	--------	*	Pottery clay, mineral water, crushed and broken stone, sand and gravel	186,322	186,322	1941
*	--------	*	Pottery clay, manganese ore, mineral water, crushed and broken stone, sand and gravel	229,269	229,269	1942
*	--------	*	Pottery clay, manganese ore, mineral water, crushed and broken stone, sand and gravel	280,119	280,119	1943
*	--------	*	Pottery clay, manganese ore, mineral water, crushed and broken stone, sand and gravel	312,849	312,849	1944
*	--------	*	Pottery clay, manganese ore, mineral water, crushed and broken stone, sand and gravel	491,435	491,435	1945
*	--------	*	Pottery clay, mineral water, crushed and broken stone, sand and gravel	871,162	871,162	1946
*	--------	*	Clay, crushed and broken stone, sand and gravel	461,179	461,179	1947
*	--------	*	Clay, crushed and broken stone, sand and gravel	389,245	389,245	1948
*	--------	*	Clay, crushed and broken stone, sand and gravel	741,278	741,278	1949
*	--------	*	Clay, crushed and broken stone, sand and gravel	450,808	450,808	1950
*	--------	*	Clay, crushed and broken stone, sand and gravel	883,789	883,789	1951
31,102	25,633	*	Clay, crushed and broken stone	1,133,635	1,159,268	1952
*	--------	*	Clay, crushed and broken stone, sand and gravel	1,041,683	1,041,683	1953
			Grand total	------------	$20,300,659	

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[11] Sand and gravel: Included with "road stone and ballast" 1910 and earlier.

[12] The term "miscellaneous stone" used in Division of Mines statistics for the first time, 1912. It is the equivalent of "macadam" plus "rubble" for prior years (Bull. 64, p. 17).

[13] "Rubble" in 1914 and earlier years.

[14] "Rubble and riprap" in 1915 and later years.

[15] "Macadam" in 1915 and earlier years.

[16] "Macadam and ballast" in 1916 and later years.

[17] The potash produced in 1922 was made from distillery waste and is not a mineral product.

[18] Pottery clay: The "pottery clay" produced in 1923-25, inclusive, was crushed brick for roofing purposes.

[19] Pottery clay: The "pottery clay" produced in 1927-39 and from 1941 to 1946 was clay shale used in the manufacture of the lightweight aggregate Haydite.

[20] Statistics for 1947 and later years have been furnished by the United States Bureau of Mines and are not in all cases comparable with figures for previous years.

[21] The Bureau of Mines does not canvass producers of mineral water.

[22] According to the Bureau of Mines classification, used in and after 1947, clay is crude material which may be and in Marin County is processed into brick and other finished articles by the producer.

[23] Data not available.

[24] Stone products were produced 1952 and 1953 in the following Bureau of Mines classification: road metal, concrete aggregate, and screenings; railroad ballast; riprap.

between the Pacific and Bay drainages is thus an irregualr line that is well within the eastern quarter of the county.

Lagunitas Creek drains the area immediately north of Mount Tamalpais, and along its upper reaches are the principal reservoirs of the Marin Municipal Water District. It flows thence northwest, cuts through Bolinas Ridge near Black Mountain, and reaches tidewater at the south end of Tomales Bay. San Geronimo Creek is a westward-flowing tributary that joins the main stream west of Lagunitas. It heads far to the east, and with Ross Valley forms a nearly water level route across the county. The pass is less than 3 miles from Fairfax and is 750 feet high. Arroyo Nicasio is another westward-flowing tributary which joins Lagunitas Creek near Black Mountain; with Gallinas Creek, which flows into San Pablo Bay, it also forms a pass across the county. Halleck Creek joins Arroyo Nicasio near Nicasio; and Shroyer Moun-

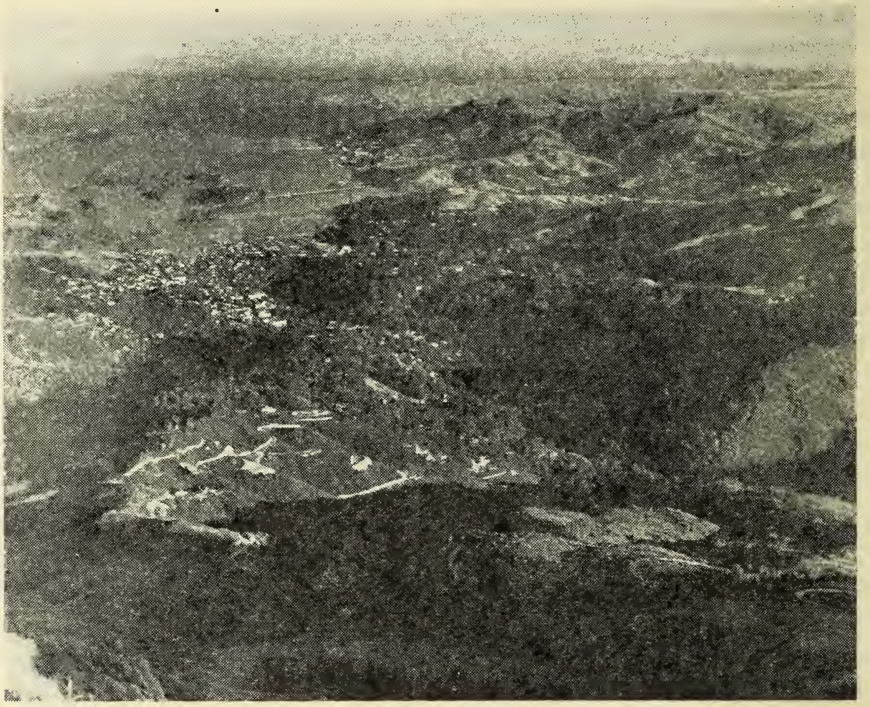

FIGURE 2. View of Mill Valley and Marin Peninsula from Mount Tamalpais. San Francisco and Bay Bridge in far background. *Photo by Charles W. Jennings.*

tain, elevation 1423 feet, is a prominent hill in the angle between these streams. This land mass culminates farther east in Big Rock Ridge with a maximum elevation of 1891 feet. A south-flowing tributary of Arroyo Nicasio heads south of Hicks Mountain, elevation 1537 feet.

Walker Creek is a stream that flows into Tomales Bay about 5 miles from the mouth and drains the area to the east and southeast. Salmon Creek and Chileno Creek are tributaries, and between Walker Creek and its tributaries lie peaks and ridges up to 1100 feet high. Salmon Creek heads in Hicks Valley in the north central part of the county and Chileno Creek heads in Chileno Valley. The divide between Chileno Creek and San Antonio Creek, which flows eastward into Petaluma Creek, is low and poorly defined. Burdell Mountain is a rounded mass about 1565 feet high in the northeast portion of the county. The relief along most of the north border, however, is comparatively low.

The Point Reyes Peninsula is of quite different topography. Southwest of Tomales Bay lies Inverness Ridge with the highest point 1408 feet at Mount Wittenberg. Northeastward the land falls away steeply to Tomales Bay, but to the southwest it slopes more gently to the relatively flat dunes and marshes of the interior. Drakes Estero is a drowned valley that reaches north from the wave-cut cliffs and beaches along Drakes Bay. These cliffs rise to heights of 500 and 600 feet at Point Reyes proper. Northward from Point Reyes the sea beach, backed by dunes, extends for more than 10 miles in a nearly straight line. Point Reyes is among the windiest and foggiest spots on the California coast.

Climate and Vegetation. The climate and vegetation are typical of those in other portions of the central Coast Ranges. The yearly average temperature at Kentfield ranges from 43.0° F. to 70.3° F. The average rainfall is 46.15 inches, most of which is received during the winter months. Most of the major streams are perennial. Of the total land area, a little more than half is grassland, 7.8 percent is covered by forests of redwood and fir, 6.8 percent by woodland (hardwood trees), and 10.2 percent by woodland and grassland. Chaparral and other brush cover 13.3 percent, and 0.3 percent is marsh. Cultivated, urban, and industrial land amounts to a little less than 10 percent.

History (Memorial and biographical history of northern California, 1891). One of the first white visitors to what is now Marin County was Francis Drake who, in the summer of 1579, spent 2 weeks in resting and in repairing his vessel. Historians believe that the anchorage was in Drakes Bay, the bight south of Point Reyes Peninsula (Jenkins, D. G., 1951).

The first permanent settlement was the Mission of San Rafael, founded in 1817, and secularized in 1834; no trace of it remains today. Non-Spanish settlers began to arrive in numbers in the Gold Rush days, but the county developed slowly. Except for a small area in the northwest, the entire county was included in Spanish land grants; and as late as 1891 half of the total area was owned by less than a dozen men.

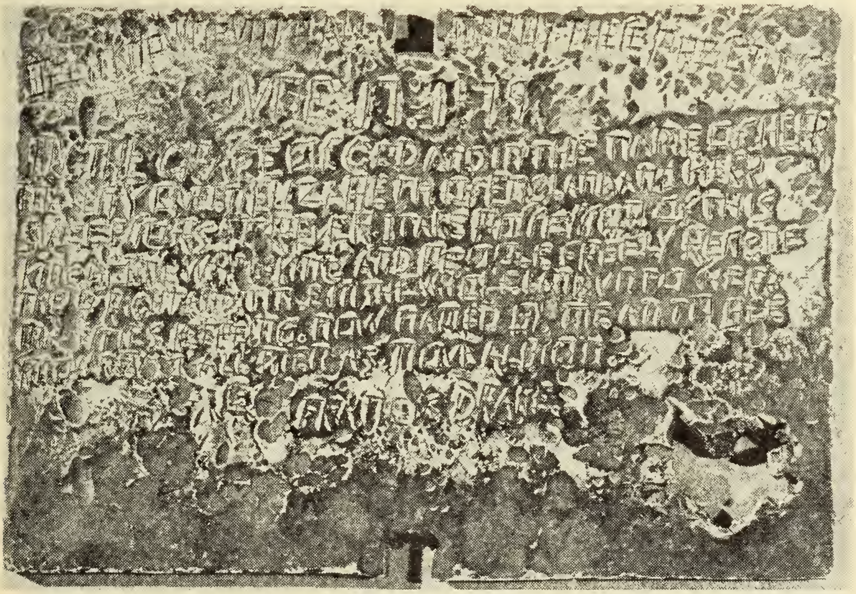

FIGURE 3. Drake's plate of brass. The inscription reads: "Bee it knowne vnto all men by these presents ivne 17 1579 By the grace of God and in the name of Herr Maiesty Qveen Elizabeth of England and Herr svccessors forever I take possession of this kingdome whose king and people freely resigne their right and title in the whole land vnto Herr Maiesties keepeing now named by me an to bee knowne vnto all men as Nova Albion. Francis Drake." The hole in the lower right-hand corner is the correct size, and probably once held "her highnesse picture and armes in a piece of sixpence current English monies," as recorded by Francis Fletcher. *Photo courtesy California Historical Society.*

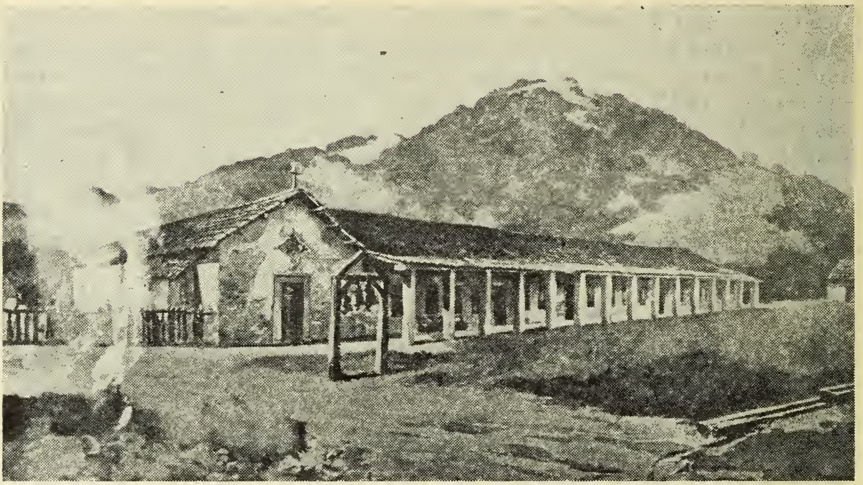

FIGURE 4. Mission San Rafael Arcángel. San Francisco Chronicle Mission Series. *Photo courtesy Society of California Pioneers.*

Marin County was one of the original 27 counties organized by the young State of California in February 1850. Most historians believe that the name was derived from El Marinero (the sailor), an Indian who was captured and Christianized by the Spanish, and who for a time lived on the larger Marin Island. Gudde (1949) however, suggests that the name may have originated with Ayala who called what is now San Rafael Bay ''Bahia de Nuestra Senora del Rosario La Marinera,'' after the patron saint of his ship.

Economic Factors. According to a special United States census, the population of Marin County in November 1953 was 107,500 of whom 15,255 lived in San Rafael, the county seat and trading center. In 1950 approximately 55 percent of the people dwelled in San Rafael and nearby cities including Belvedere, Corte Madera, Fairfax, Larkspur, Mill Valley, Ross, San Anselmo, and Sausalito that are within convenient commuting distance of San Francisco. It seems likely that a substantial part of the remaining 45 percent also live in the same part of the county. Other communities include Novato, in the farming area in the northeast part of the county, Nicasio in the center of the county, Bolinas and Stinson Beach on the ocean shore, and Inverness and Point Reyes Station in the Tomales Bay area.

The principal industries are agriculture, manufacturing, and mining. The value of agricultural products, including dairy, poultry, and truck farm products, was $8,574,000 in 1944. Light manufacturing is second in importance, and in 1948 articles were produced having a value added in the manufacturing processes of $3,333,000. In 1953 sand, gravel, stone, and clay valued at $1,041,683 were produced.

The eastern portion of Marin County is served by the Northwestern Pacific Railroad which connects the San Francisco area with Eureka. The main line runs through San Rafael and Novato, while branches serve Larkspur, Mill Valley, and Sausalito. A direct rail connection is provided with the parent, the Southern Pacific Company, by means of the Schellville interchange on the Sonoma branch. Service to San Francisco and connection with the Santa Fe Railway is by means of a car ferry from Tiburon.

The Redwood Highway, U. S. Highway 101, is a first class road that runs from the Golden Gate Bridge, through San Rafael and Novato in the eastern portion of the county, and north to Petaluma and Eureka. State Highway 37 diverges from the Redwood Highway between San Rafael and Novato and connects with the Black Point cut-off which joins U. S. Highway 40 near Vallejo.

Other portions of the county are served by a network of paved secondary roads. State Highway 1, the coast road, crosses the county south of Mount Tamalpais and runs northwestward through Bolinas, Point Reyes Station, and along the northeast shore of Tomales Bay into Sonoma County. The Sir Francis Drake Highway runs from Point San Quentin to Point Reyes by way of Ross Valley, San Geronimo Creek, Point Reyes Station, and Inverness. Construction on a bridge across San Pablo Strait to replace the existing vehicle ferry began in 1953. Another cross county road runs from Novato to Marshall on Tomales Bay, and the Petaluma-Point Reyes road runs southwestward across the county.

GEOLOGY

Perhaps the most striking geologic feature of Marin County is the San Andreas fault zone which occupies the rift valley through Bolinas

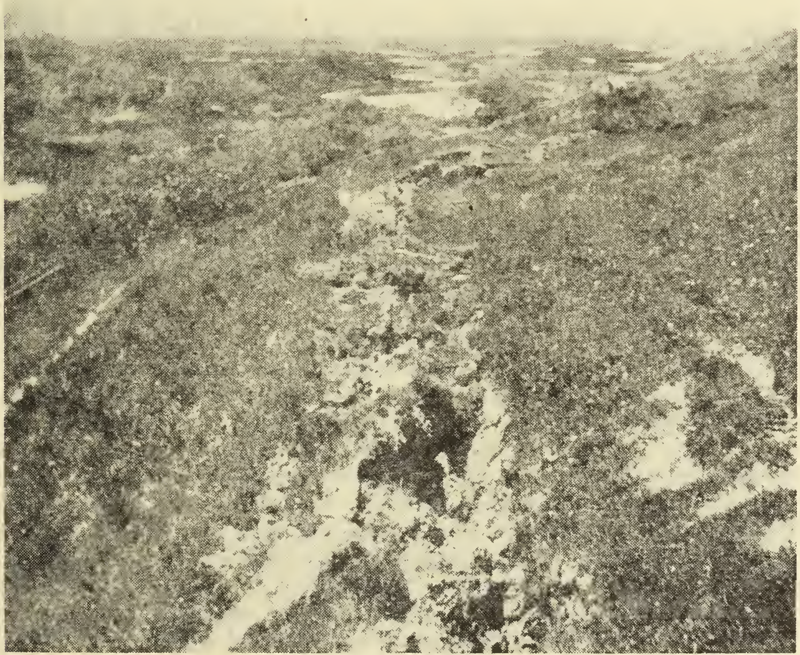

FIGURE 5. Detail of fissured earth north of Bear Valley Ranch, 3 miles northwest of Olema, Marin County. Marshlands of Tomales Bay may be seen in the background. 1906. *Photo from J. C. Branner collection, courtesy Stanford University.*

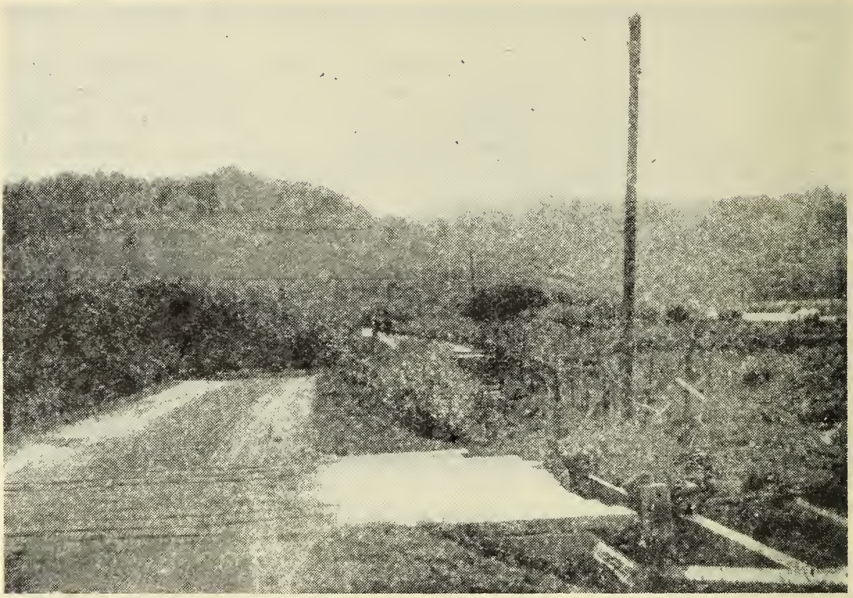

FIGURE 6. Photo taken in 1906 showing view southwest down wagon road that crossed Tomales Valley, from Point Reyes Station to the mouth of Papermill Creek. San Andreas fault movement of April 18, 1906, offset the two segments of the road 20 feet. *Photo by G. K. Gilbert.*

Lagoon, Olema, and Tomales Bay. The San Andreas fault is the boundary between two regions of different geology and topography that extend southeastward into San Francisco and San Mateo Counties and northwestward into Sonoma County. To the east lies the San Francisco-Marin structural block which includes all of Marin County except the Point Reyes Peninsula. West of the San Andreas fault is the Point Reyes Peninsula, which comprises the Marin County portion of the Montara structural block. The dominant formation of the San Francisco-Marin block is the folded and faulted sandstone of the Franciscan group of late Jurassic (?) age. On the Point Reyes Peninsula Tertiary marine sediments lie on a granitic basement.

San Andreas Rift Zone

The San Andreas fault is a major structural feature of California that can be traced from Point Arena in Mendocino County southeastward into Imperial County. In the San Francisco area it roughly parallels the coast. It crosses Marin County through Tomales Bay and Bolinas Lagoon, passes west of the Golden Gate, and enters San Mateo County near Mussel Rock. According to Taliaferro (1943a), the principal displacement, which has been horizontal with the east block moved south relative to the west block, began in late Pliocene or perhaps Pleistocene time; and the cumulative horizontal displacement is probably a mile or less. The San Andreas fault is a geologically young feature that seems to have followed a zone of weakness along an earlier fault or series of faults. The principal displacement on these earlier faults may have been vertical.

The most recent notable movement on the northern California section of the San Andreas fault resulted in the San Francisco earthquake of 1906. The greatest observed displacement was at the Bear Valley Ranch near Olema, Marin County, where it amounted to 21 feet. A fault fissure, now largely earth filled, may still be seen.

The trace of the San Andreas fault through Marin County is a rift valley, of which Tomales Bay and Bolinas Lagoon are drowned portions. Where it is exposed between these two bodies of water it is a mile-wide zone of parallel fractures that is characterized by haphazard drainage. The exposed rocks in the rift zone are the deeply weathered and crushed sediments and associated igneous rocks of the Franciscan group.

San Francisco-Marin Block

Franciscan Group. The oldest rocks of the San Francisco-Marin block are those of the Franciscan group. The most abundant rock is a medium to coarse grained, dark gray, feldspathic marine sandstone. Although much of it is faulted and broken, unfractured bodies exist and are important sources of crushed and broken stone. Bits of carbonized wood are present, and thin seams of impure low-rank lignite have been found.

Perhaps 2 percent of the Franciscan group consists of limestone, black shale, conglomerate, and radiolarian chert. In San Francisco and southern Marin county Lawson (1914) divided the group into two sandstone formations, two chert formations, and a limestone formation, but these cannot be projected from the type localities. Interbedded with the sandstone are lenses of thin-bedded radiolarian chert that range in thickness from a few feet to more than 300 feet. Typically, the lenses consist of reddish-brown chert layers 1 inch to 3 inches thick separated by thin partings of red shale. These rocks are particularly well exposed along the Waldo grade and in Sausalito. More massive bodies of green and red jasper occur and have furnished limited amounts of gem material. Oxidized manganese ore is associated with the chert bodies throughout the Coast Ranges. In general, the deposits in Marin County are small and siliceous, but manganese ore has been obtained from some of them.

Igneous rocks associated with sediments of the Franciscan group include intrusive bodies of diabase and flows of basalt, the latter commonly having spheroidal or ''pillow'' jointing. These rocks, which crop out over areas of as much as 5 square miles, are commonly altered to greenstone. Another type of intrusive that cuts the Franciscan rocks is serpentine. Cinnabar and nephrite jade are found in Marin County associated with serpentine. Chromite, asbestos, magnesite, soapstone, and nickel also are associated with serpentine, and occurrences of some of these commodities have been reported in Marin County.

Locally, the Franciscan sediments and associated igneous rocks have been converted to a colorful assemblage of metamorphic rocks, the glaucophane schists. The unusual mineralogy of these rocks, which are named after the characteristic blue amphibole, glaucophane, which is commonly dominant, has stimulated widespread interest. One of the classic areas which have been studied in this connection is Tiburon Peninsula. The mineral lawsonite was originally described from this locality (Ransome, 1895); and all of the 30-odd mineral species, many of them rare elsewhere, which are known from the glaucophane schist assemblage are to be found in this vicinity (Switzer, 1951). Slabs and

Summary of economic geology of Marin County.

Geologic age		Formations	Distribution	Rock types	Mineral product
Quaternary	Recent	Alluvium	Stream channels	Sand and gravel	Aggregates
		Dunes	Ocean beaches	Sand	
Tertiary	Upper Pliocene	Merced	North border of Marin County and west shore of Bolinas Lagoon	Tuffaceous sandstone with conglomerate lenses	
		Sonoma volcanics	Burdell Mountain and vicinity	Andesite	Aggregates, paving blocks
	Miocene	Monterey	Point Reyes peninsula	Siliceous shale, clay shale, sandy shale, sandstone	Gas seeps and asphalt deposits
		Laird	Point Reyes and Tomales Point	Coarse-grained sandstone and conglomerate	
Cretaceous (?)		Novato	3½ square mile area east of Novato	Well rounded cobbles in a coarse sand matrix	Aggregates
Upper Jurassic (?)		Serpentine	Elongated, sill-like masses intrusive into the Franciscan group	Serpentine	Nephrite jade, chromite
		Franciscan group	The dominant formation east of the San Andreas rift zone	Sandstone	Jetty stone, aggregates; host for occurrences of gold and ore minerals of silver, lead, copper and mercury
				Shale	Brick, lightweight aggregate
				Chert	Manganese, aggregates, gems
				Diabase and basalt (greenstone), in part intrusive	
				Glaucophane schist	Patio stone
				Limestone (minor)	Lime
Paleozoic (?)		Quartz diorite	Inverness Ridge and Point Reyes	Fractured and deeply weathered	
		Sur series	Inverness Ridge	Limestone	Lime, tungsten
				Schist and quartzite	

blocks of glaucophane schist from Tiburon Peninsula and elsewhere in Marin County have been used locally as garden stone and for the construction of decorative retaining walls.

The base of the Franciscan group has not been found; if the top exists in Marin County, it has not been recognized. Although fossils satisfactory for age determination have not yet been reported from rocks of the Franciscan group in Marin County, a Cretaceous ammonite was recently found in Franciscan(?) sandstone on the sea cliff on the San Francisco shore of the Golden Gate (Schlocker, 1954). Elsewhere in the Coast Ranges the Franciscan group has been determined from indirect evidence to be of late Jurassic age (Taliaferro, 1943b).

Novato Conglomerate. The Novato conglomerate is confined to a 3½-square-mile area northeast of Novato. The exposure is surrounded by alluvium except along a portion of the west boundary where the formation rests on serpentine and is in fault contact with the Sonoma volcanics.

The Novato conglomerate is composed of well rounded pebbles and cobbles of quartz, chert, schist, quartzite, and quartz porphyry in a matrix of slightly consolidated, coarse sand. The material ranges from pebbles as small as a quarter of an inch in diameter to cobbles 6 inches in diameter or, rarely, larger. Lenses of sand similar to the matrix are present, but comprise a minor proportion of the whole. The Novato has been tentatively dated as Cretaceous from a fossil fragment of probable Cretaceous age which could, however, have been derived from older rocks (Weaver 1949a, p. 46). This formation is an important source of aggregates.

Sonoma Volcanics. The Sonoma volcanics, of late Pliocene age, rest unconformably on the Franciscan group at Burdell Mountain and vicinity in the northeastern portion of the county. These outcrops are outliers of much larger bodies of the Sonoma volcanics to the east and north. On Burdell Mountain the formation is predominantly andesite, but in other areas it contains much tuff as well as sandstone and conglomerate. Huge quantities of andesite paving blocks have been produced on Burdell Mountain, and in the summer of 1954 a crushed stone plant was under construction.

Merced Formation. The marine Merced formation rests on the eroded surface of the Franciscan group along the north edge of Marin County. In this area it consists of a maximum of 100 feet of tuffaceous sandstone and conglomerate lenses. To the north in Sonoma County the Merced interfingers with the Sonoma volcanics and is in part contemporaneous with them (Weaver 1949b, p. 48). From abundant fossils the Merced formation is considered to be late Pliocene in age (Travis 1952, p. 21).

Structure of the San Francisco-Marin Block. The rocks of the Franciscan group are folded into a series of nearly parallel, northwest-trending anticlines and synclines. The basalt and diabase bodies and the serpentine sills likewise are elongated in a northwest direction. Faults and shear zones are very numerous but are difficult to trace. One exception is the northwest-trending Burdell Mountain fault along which the Sonoma volcanics are in contact with the Franciscan group on the northeast slope of Burdell Mountain and with the Novato conglomerate northeast of Novato. The southwest block has dropped at least 400 feet relative to the northeast block (Weaver 1949b; p. 67). The structures in the Franciscan rocks are cut off on the west by the San Andreas fault which crosses them at a small angle.

The Sonoma volcanics and the Merced beds were deposited on an eroded surface of low relief, and in general, the dips in these younger formations are low. The Merced formation probably once covered a large part of Marin County, but it has since been stripped off except where it has been protected from erosion.

Montara Block

The oldest rocks in the Montara block (Point Reyes Peninsula) are some small, isolated roof pendants of metamorphic rocks that may be the equivalent of the Sur series of Monterey County. Crystalline limestone and biotite schist crop out on the northeast slope of Inverness Ridge. Small bodies of limestone are probably more widely distributed on Inverness Ridge than the geologic map of Weaver (Weaver, 1949b, plate 9) suggests. However, the limestone is in the form of small, detached remnants, or roof pendants intruded by the younger quartz

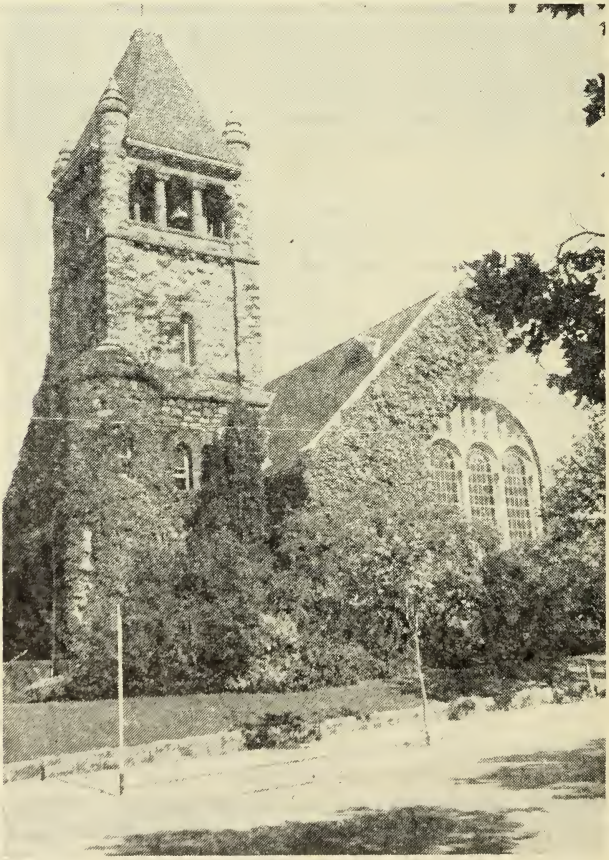

FIGURE 7. First Presbyterian Church, 5th and D Streets, San Rafael. Constructed of Franciscan sandstone from the Hotaling quarry.

diorite. Occurrences of limestone are known on the Noren property near the junction of the Bear Valley road and the Sir Francis Drake Highway, on the Lockhart property west of Inverness Park, and on the Bender property west of Willow Point. Roof pendants of biotite schist are also known. Deposits of scheelite are associated with the limestone and schist roof pendants and were the first confirmed occurrences of scheelite in the metamorphic rocks of the California Coast Ranges.

Quartz diorite crops out on Inverness Ridge from near Olema to Tomales Point. The same rock is exposed in the sea cliffs at Point Reyes proper and is believed to form the basement beneath the younger rocks in the entire Point Reyes Peninsula. The quartz diorite is a gray, medium-grained rock composed principally of quartz, feldspar, hornblende, and biotite. Pegmatite and aplite dikes as well as inclusions are present. The age is not known.

Tertiary sediments occupy a broad down warp in the quartz diorite. The Laird sandstone, possibly of early Miocene age, is a basal conglomerate exposed on Tomales Point and at Point Reyes. Overlying the Laird sandstone is the Monterey formation, a sequence of siliceous shale, clay shale, sandy shale, and sandstone of middle to late Miocene age. (Anderson, 1899; Dickerson, 1922, pp. 538-540; Weaver, 1949b, p. 40.) In the Point Reyes quadrangle the Monterey shale is 2300 feet thick but is more than 8000 feet thick to the southeast near Bolinas. Gas and oil seeps, particularly at Duxbury Point, give evidence of the presence of petroleum, but oil has not yet been found in commercial amounts in Marin County. The Miocene rocks have been strongly folded into a series of northwest-trending anticlines and synclines that are well exposed on the sea cliffs.

Along the west shore of Bolinas Lagoon the slightly folded Pliocene Merced formation unconformably overlies the Monterey shale.

MINES AND MINERAL DEPOSITS

Stone Industries

The stone industries comprise the most important branch of the mineral industry in Marin County. The principal products are crushed and broken stone with smaller but significant amounts of sand and gravel. Prior to 1900 paving blocks were produced in large quantities, and in the early years of the twentieth century a modest output of dimension stone was recorded from the county. In recent times some flagstone has been quarried from glaucophane schist on the Tiburon Peninsula.

Most of the stone has been and is obtained from massive, hard "blue" sandstone members of the Franciscan group. This type of rock is quarried today at San Pedro Point and Greenbrae and prior to 1920 at a number of other localities. They include the Escalle quarry between Larkspur and Kentfield, the Hotaling quarry on Clark Street, San Rafael, quarries in San Anselmo at one time worked by the Marin Rock Company and others, a quarry in Mount Tamalpais Cemetery, San Rafael, and the Point Bonita quarry at Fort Barry. Other sources are the Novato conglomerate at Black Point, andesite flows of the Sonoma volcanics at Burdell Mountain, and chert of the Franciscan group. Quarries in chert include the Forbes quarry, San Rafael, the Hoffman quarry on U. S. Highway 101, and a quarry in San Rafael once operated by the San Rafael Development Company. The basalt and diabase associated with the Franciscan group have been used on only a small scale, primarily because none of these rocks occur in the more thickly settled portions of the County. Sand and gravel has been taken from Lagunitas Creek.

Although the ''blue'' sandstone is poorly adapted to the purpose, some dimension stone has been made from it. The principal source has been the Hotaling quarry which in 1914 had a total production of 10,000 cubic yards of curbing and rough building stone in addition to crushed stone. The First Presbyterian church, 5th and D Streets, San Rafael, is built of stone from this quarry. Smaller amounts of curbing and rough building stone were taken from the Mount Tamalpais Cemetery quarry and quarries operated by Dodge and Croker and the Raymand Land Company near San Anselmo. A limited amount of andesite for retaining walls and foundations from Burdell Mountain was used in San Francisco before the earthquake and fire of 1906. The principal product of the Burdell Mountain quarries has been paving blocks. In the 19th century hundreds of thousands of blocks were hand shaped from the tough andesite and shipped by barge via Petaluma Creek to San Francisco. The De Long quarry and the Taylor quarry were in operation as late as 1894, and the last recorded production of paving blocks in Marin County was in 1895.

Crushed and broken stone include rubble and rip rap, macadam and ballast, and concrete aggregate. According to the classification of the United States Bureau of Mines, rubble is a crude form of dimension stone having one flat face that is used for foundations and rough walls; and as pointed out above some stone produced in Marin County has been so used. Most of the rubble from Marin County, however, has been coarse broken stone for the construction of sea walls, jetties, and levees; and it has come from quarries that produce crushed and broken stone, not dimension stone. Perhaps jetty stone would be a more descriptive designation. It includes face rock ($\frac{2}{3}$ cubic foot to 40 cubic feet), cap rock (3 tons to 8 tons), and core rock (27 cubic inches to 8 cubic feet). One grade used by the Corps of Engineers and locally known as Engineers' rock consists of rectangular pieces weighing between 15 and 200 pounds. The average weight is 75 pounds, and not less than 30 percent of the pieces can weigh under 30 pounds. Marin County furnished at least a portion of the stone for the construction of the wharves along the Embarcadero and the Santa Fe fill in China Basin, San Francisco. In modern times the Alameda Naval Base alone required a million tons of jetty stone, and currently it is being used by the Corps of Engineers for levees along the Sacramento River.

Stone for macadam and ballast consists of angular, sized, crushed stone for roads as well as railroad ballast. In making roads crushed stone is used for base courses, for waterbound macadam, bituminous macadam, and bituminous concrete. The particle size of road stone ranges from 3 inches to minus $\frac{1}{4}$ inch, and the standard size for railroad ballast is $2\frac{1}{2}$ inches to $\frac{3}{4}$ inch. In the past the Northwestern Pacific Railroad and its predecessors obtained ballast and fill from quarries at Black Point, Tiburon Point, and Waldo.

Concrete aggregate is sized, angular crushed stone similar to road stone and ballast but of more exacting specifications. Today the only source in Marin County, with minor exceptions, is the Novato conglomerate; but formerly, when specifications were less rigid, most of the quarries furnished it. The Point Bonita quarry at Fort Barry, for example, was opened in 1890 to supply concrete aggregate for fortifications on the post.

Sand and gravel are unconsolidated granular materials ranging in size from 3½ inches to 200 mesh. Sand is considered to be that which is finer than ¼ inch. The principal uses are as aggregates for concrete and plaster. If the cobbles and larger sizes of gravel are crushed, the product is indistinguishable from crushed stone prepared from quarried rock.

In addition much unsized, pit run material is taken for fills. Whatever material is available close to the job is used, and many times pits are opened especially for one job. Pits that have furnished this class of material are widely distributed, and no attempt is made to describe them in this report.

Black Mountain Quarry. The Black Mountain quarry, on the lower southwest slopes of Black Mountain near the junction of Arroyo Nicasio and Lagunitas Creek, is on property belonging to J. S. Burdell of Petaluma. The Marin Gravel Company produced crushed stone here until 1953 when the plant was dismantled and moved to a locality near Novato, described in another section of this report. The Black Mountain quarry is idle.

The quarry has been opened in Franciscan chert near the hanging wall of a lens that strikes northwest and dips about 40 degrees northeast. From the toe to the brow of the face the following units are exposed: thin bedded black shale, thin bedded chert with red shale partings, massive chert, and porphyritic lava. Similar lava crops out on the slope above the quarry. The contact between the chert and the lava is a zone of fault breccia containing chert, shale, and lava.

The proportion of shale and soft altered lava to chert in the material remaining in the quarry is high.

*Black Point Operation of Black Point Aggregates, Incorporated (Rock Products, 1953).** Black Point Aggregates, Incorporated, produces crushed stone and washed sand and gravel for all purposes including concrete aggregate. Marshall Smith is President and General Manager. The plant is west of Black Point Station and south of State Highway 37, and the company's office is at 115 Woodland Avenue, San Rafael. The first full month of capacity production was obtained in May 1954.

Raw material is obtained from the Novato conglomerate which at Black Point consists primarily of tough, rounded pebbles and cobbles in a sandy matrix. The presence of soft cobbles as well as of tough cobbles with soft, weathered shells necessitates the thorough scrubbing and washing of the raw material. Black Point Aggregates, Incorporated, is believed to be the first to produce high quality aggregates successfully from the Novato conglomerate.

The plant occupies a southwest-trending gully that faces Novato Creek, and the raw material is brought down to it from the hill to the southeast. Bulldozing suffices to loosen the conglomerate and move it to a loading chute above the plant. Large cobbles that are set to one

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* Plant visit May 28, 1954.

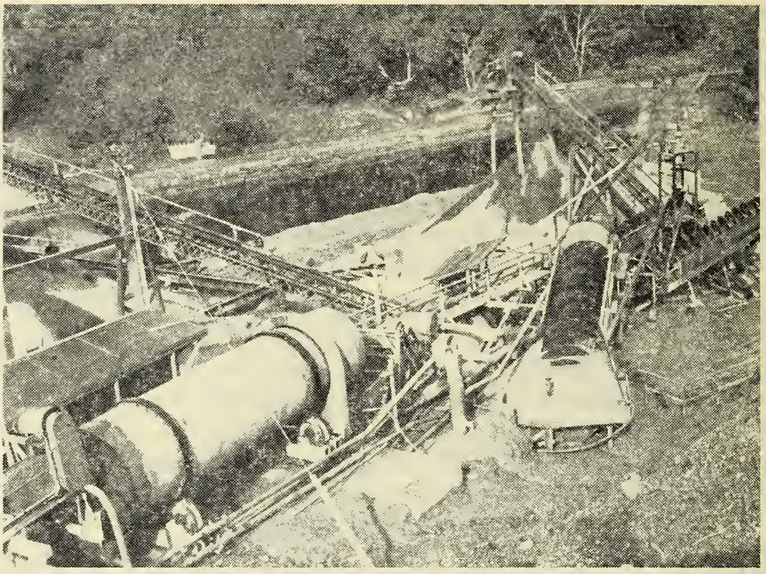

FIGURE 8. Black Point aggregates plant. Plant feed (Novato conglomerate) is scrubbed, crushed, and screened. Gravel passes through the selective crusher (left center) and via the inclined conveyor to sizing screens. The sand goes through the primary classifier (right center), thence through a battery of attrition cells and two secondary classifiers (right) to the sand stock pile.

side comprise a small proportion of the raw material handled. The feed is first treated with a Bodinson scrubber, a revolving cylinder in which water sprays and the tumbling action free the cobbles from the matrix. The product of the scrubber is then sent to a Cedar Rapids double-decked vibrating screen that separates the sand from the gravel.

Fines from the screen are first treated with a 60 inch by 27 foot Wemco spiral classifier that removes clay and fine sand in the 200 mesh to 325 mesh range. The sand product of the classifier at 60 percent solids, is treated in a Wemco attrition machine of eight cells. Each cell, which is rubber lined, contains a number of rubber-covered impellers mounted on a vertical shaft and driven by a 10 horse power electric motor. The cells are arranged in two series of four, and the discharge from each series is treated in a secondary spiral classifier. The overflows from the two secondary classifiers are recirculated through the scrubber, and the sands are stockpiled over a concrete tunnel equipped with draw points. Late in May 1954 the company installed a 20-inch Krebs wet cyclone with 8-inch discharge and 5-inch suction to treat the Wemco classifier overflow. Sand in the 200 to 325 mesh range is recovered and added to the coarse sand. It is hoped that a market for the clay will be found. The sand thus produced meets the specifications of the California Division of Highways for concrete sand in particle size distribution as well as in all other physical properties.

Gravel is separated from the feed with the Cedar Rapids screen. Plus $\frac{1}{2}$-inch material, which remains on the top deck, is reduced with a jaw crusher and joins the material that remains on the lower deck. About 25 percent of the gravel requires crushing. The gravel then goes through a scrubber and selective crusher of local design in which the

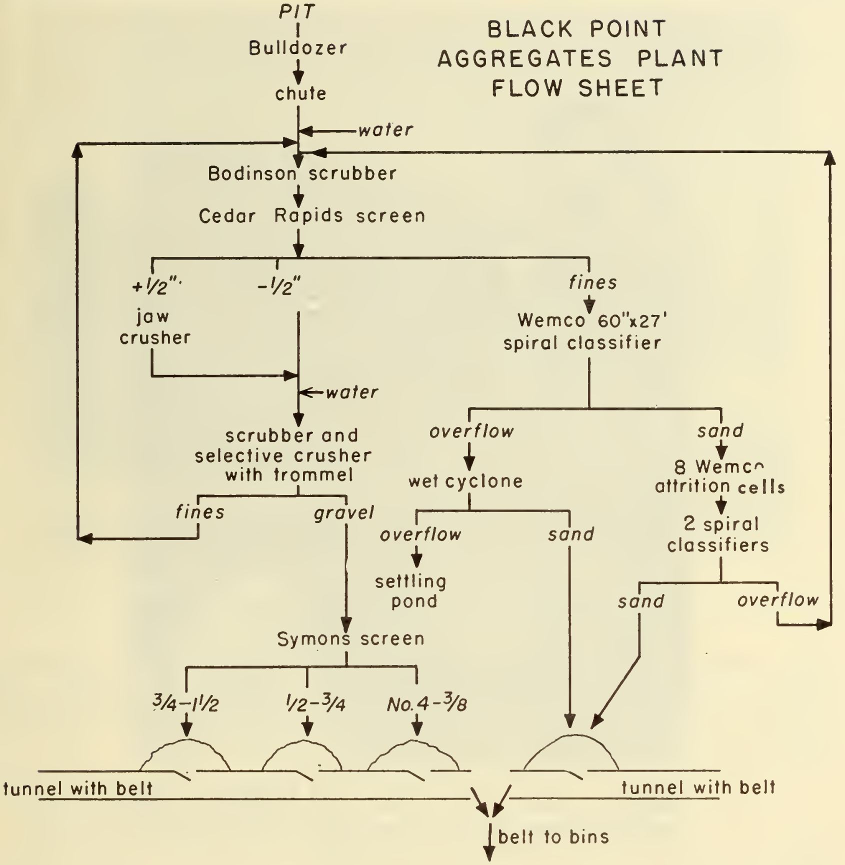
BLACK POINT AGGREGATES PLANT FLOW SHEET
PIT
Bulldozer
chute
water
Bodinson scrubber
Cedar Rapids screen
+1/2"
-1/2"
fines
jaw crusher
Wemco 60"x27' spiral classifier
water
scrubber and selective crusher with trommel
overflow
sand
fines
gravel
wet cyclone
8 Wemco attrition cells
overflow
sand
settling pond
2 spiral classifiers
sand
overflow
Symons screen
3/4-1 1/2
1/2-3/4
No. 4-3/8
tunnel with belt
tunnel with belt
belt to bins

FIGURE 9. Flow sheet, Black Point aggregates plant.

percent of soft rock is reduced from 6 to $1\frac{1}{2}$. The machine consists of a revolving cylinder containing two pairs of railroad locomotive axles in tandem followed by an iron ball about 1 foot in diameter. Soft rock that is pulverized by these weights as the cylinder revolves is freed from the gravel with water sprays and removed by a 5-foot trommel screen fastened to the discharge end of the cylinder. The fines screened out are returned to the first scrubber, and the washed gravel is elevated to a Symons screen. Three sizes are produced; $\frac{3}{4}$ inch to $1\frac{1}{2}$ inch, $\frac{1}{2}$ inch to $\frac{3}{4}$ inch, and 4 mesh to $\frac{3}{8}$ inch. The gravel is stored over a single concrete tunnel with a draw point for each size. This gravel is the only material suitable for concrete aggregate produced in Marin County. In tests performed by Abbot A. Hanks, Inc., the gravel had a grading loss of 13.4 percent after 10,000 revolutions in the wet shot rattler. In the sodium sulfate soundness test, the $1\frac{1}{2}$ inch to $\frac{3}{4}$ inch size suffered a 0.53 percent loss, the $\frac{3}{4}$ inch to $\frac{3}{8}$ inch, 1.50 percent, and the $\frac{3}{8}$ inch to 4 mesh, 5.66 percent.

Blended aggregate is prepared according to the particle size distribution of the customer's specifications by mixing the required amounts of sand and the three sizes of gravel on belts. Belts fed from the draw

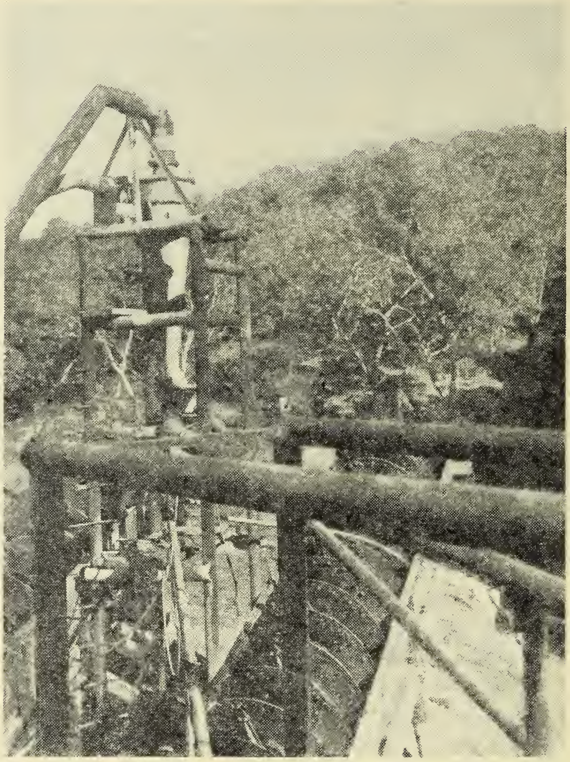

FIGURE 10. Wet cyclone, Black Point aggregates plant. The overflow from the primary classifier enters the cone tangentially near the top. Fine sand is recovered from the apex, and water and clay drawn from the top are run to settling ponds.

points beneath the stock piles discharge onto an additional belt that carries the blended aggregate to either of two truck loading bins.

Water required for washing amounts to 1000 gallons per minute per 100 tons of feed. Fresh water is obtained from the drainage ditch of the Sartori farm and pumped to the plant through two 4-inch lines. Because the water requirements are larger than originally anticipated, the supply from the ditch is supplemented with water from a storage pond that is filled from the ditch at night. The tailings, the overflow from the wet cyclone, pass through two settling ponds, and clear water returns to the ditch.

*Burdell Mountain Operation, Marin Gravel Company**. The Marin Gravel Company is constructing a plant for the production of crushed stone on the Julia C. Bodkin property, formerly the J. W. Taylor ranch. H. C. Phillips, a copartner, is in charge of the operation.

The plant is at the foot of the southeast spur of Burdell Mountain about half a mile west of U. S. Highway 101 and 2 miles north of Novato. At the plant site sandstone of the Franciscan group and associated serpentine crop out, but a short distance up the hill lies the lower edge of a black, finely porphyritic andesite member of the

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* Plant visit June 9, 1954.

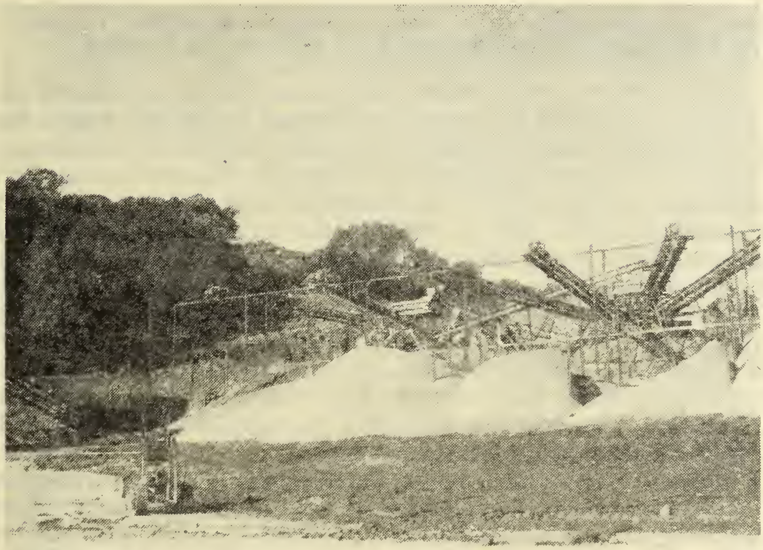

FIGURE 11. Burdell Mountain aggregates plant, Marin Gravel Company. Raw material is andesite of the Sonoma volcanics.

Sonoma volcanics that crops out over much of Burdell Mountain. Seismic tests indicate that the andesite between the plant site and the summit is 200 feet thick and that it lies on an unidentified but probably hard rock. At the lower edge of the andesite is a long idle and overgrown quarry with a face 50 feet high and 200 feet long. This was the Joseph Taylor paving block quarry, last worked in 1894.

Although a substantial quantity of waste had accumulated from the paving block operation, the Marin Gravel Company plans to reopen the old quarry. A plant of 1500 tons daily capacity is under construction, and in June 1954 the principal pieces of equipment had been installed. Some of the machinery was brought from a plant that the Marin Gravel Company formerly operated on Lagunitas Creek near Point Reyes Station.

The primary crusher will be a 36 inch by 24 inch jaw crusher. In order to remove trash, dirt, and soft rock, the crusher product will pass over an inclined Symons bar screen. The plus ½ inch stone will be stock piled over a concrete tunnel equipped with a draw point for feeding a conveyor belt. Secondary crushing will be accomplished with an Austin-Western jaw crusher and a Telsmith gyrasphere no. 36 crusher. It is planned to screen the crushed stone into six sizes ranging from 2½ inches to dust and to stack these products over concrete tunnels. Blended aggregate containing any proportion of sizes desired will be sent either to truck loading bins or to an asphalt batch mixing plant.

Escalle Quarry. The Escalle quarry, Larkspur, is on the property of A. A. Tiscornia. A limited amount of crushed stone was produced in the 1910-1915 period, but the quarry has been idle since that time.

The quarry face, which is about 100 feet long and 30 feet high, has exposed ''blue'' Franciscan sandstone associated with as much as 30 percent of black shale. In a limited reconnaissance the lignite seam reported by Bradley (Bradley 1916, p. 254) was not found.

*Forbes Quarry.** The Forbes quarry is at the end of Quarry Road, San Rafael. At present the property is owned by the Marvelous Marin Realty Company, and it is leased to Jensen and Pitts, contractor, of San Rafael who obtain pit run material for fill. The Forbes quarry was in operation as early as 1893, and probably most of the stone obtained from it was quarried prior to 1913. In the early operation the quarry furnished aggregate for concrete as well as for paving.

The quarry has been opened in a body of chert at least 200 feet thick that strikes northwest and dips northeast at an average of perhaps 40 degrees. Most of the chert is the brownish, thin bedded material typical of the Franciscan group, but the thickness of red shale between the chert layers is small. The footwall of the chert as well as the sheared and shattered sandstone beneath it is exposed at the upper end of Quarry Road near the quarry entrance.

The quarry consists of a lower, vertical bench and an upper more gently sloping bench. The vertical bench, which has been enlarged from a through cut in the footwall, is 100 feet high; and the lower quarry is about 200 feet in diameter. The upper slopes have been cut in the chert above the northern, northeastern, and eastern sides of the lower quarry.

Because the quarry is close to dwellings, the City of San Rafael does not permit blasting or the operation of crushing equipment. Chert is removed from the upper, gently sloping benches with a rooter and bulldozed to the lower quarry floor where it is shoveled into trucks. The wear on the rooter teeth is severe.

*Greenbrae Quarry, Hutchinson Company.*** The Hutchinson Company produces crushed and broken stone from a quarry northeast of the junction of U. S. Highway 101 and the Sir Francis Drake Highway at Greenbrae. The main office is at 7360 Schmidt Lane, El Cerrito. Forest E. Brown is President of the company, and the superintendent of the quarry is L. A. Clapp. Quarrying began in July 1925, and production was achieved the following March.

Two adjoining quarries have been opened in a hard "blue" sandstone member of the Franciscan group. The rock is a medium-grained, blue-gray graywacke with abundant fragments of black shale and calcite veinlets as much as half an inch thick. It is composed of angular grains of quartz and plagioclase feldspar well cemented by calcite and chlorite. Similar rock crops out to the east in the San Quentin Prison grounds and at San Quentin Point. In general the strike is easterly, and dips are steep to the north, but in detail the structure is complex. In the easterly quarry, which is the one now worked, the body of blue rock is about 200 feet thick. It apparently plunges to the east at a gentle angle because in that direction the thickness of a black shale that overlies the sandstone increases. On the west side of the quarry, shale and a minor amount of limestone have apparently been folded down into the blue sandstone. In the toe of central part of the face shale is exposed, but blue rock is believed to lie below the quarry floor.

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* Visited September 2, 1954.
** Plant visit June 9, 1954.

The original quarry is a short distance west of the active quarry and is bounded on the east by a north trending fault along which blue rock and shale are in contact. Quarrying on the west side was limited by U. S. Highway 101.

The active quarry is worked with three benches, an upper bench with a maximum height of 75 feet, a middle bench 150 feet high, and a 40 foot bench at the base. Holes are made with wagon drills and shot with special Atlas explosives. Because of the proximity of dwellings, blasts are limited to a maximum of 1000 pounds of explosive, and secondary blasting has been eliminated. Large pieces are now reduced with a 3400 pound drop ball operated by a 20 ton Lorraine truck crane.

Broken stone is handled with three 1½ cubic yard shovels including a Bucyrus-Erie, a Northwest number 5, and a Northwest number 6. Stone is hauled from the quarry in 15-cubic yard Euclid trucks, and for other hauling about the plant 10-cubic-yard Hug trucks are used.

The plant has a capacity of 2000 tons a day of jetty stone and crushed stone for paving. Some of the crushed stone is used as concrete aggregate in cases where the specifications require that a portion of the aggregate be angular. The primary crusher is a 36 inch by 42 inch jaw crusher, and secondary crushing is accomplished with a 4½ foot Symons cone crusher followed by two three foot Symons cone crushers. Jetty stone, comprising pieces weighing from 200 pounds to one pound, is drawn from the surge bin that holds that primary crusher product.

The crushed stone is sized with four flat Symons screens mounted over wooden, concrete-lined bins. The screens as well as the secondary crushers are housed and provided with a dust collecting system. The following sizes of crushed stone in addition to jetty stone can be produced.

2½ inches to 1½ inches
1½ inches to ¾ inch
¾ inch to ¼ inch
½ inch to ¼ inch
⅜ inch to 6 mesh
⅜ inch to 10 mesh
¼ inch to 10 mesh
¼ inch to 200 mesh (rock dust)

The crushed stone bins are provided with chutes for the loading of cars and trucks, or alternatively the chutes can discharge onto a common belt for producing blended aggregate. Additional storage is obtained by the use of outside stockpiles served by steam and diesel locomotive cranes. A substantial portion of the output is shipped by barges which are either belt or truck loaded in nearby Corte Madera Creek.

All of the rock dust and a portion of the coarser aggregate are consumed in a 4000 pound asphalt batch mixing plant. In addition some purchased sand is required. The various sizes of crushed stone are drawn from the main stock and stored in special bins that serve the asphalt plant. Aggregates are mixed in the proportions specified by the customer and passed through a rotary drier that is operated in closed circuit with an efficient dust collector that permits practically no dust to escape into the atmosphere. The dried aggregate is then screened, the proportions of the sizes checked and adjusted if necessary, and remixed. Finally the batch is mixed in a pug mill with the specified amount of heated oil. Some asphalt mixes must be used at once, while others can be stored.

Hotaling Quarry. The Hotaling quarry is near the south end of Clark Street, San Rafael, on land belonging to William S. Nock. A narrow and overgrown footpath leads from the end of Clark Street about 100 yards to the quarry which lies a little to the east of the prolongation of the street. This quarry furnished crushed stone and dimension stone from about 1890 to the World War I period.

The quarry, which is circular in plan, is 300 feet in diameter; and the face is about 75 feet high. The quarry floor is choked with brush and young trees. The principal rock exposed is a massive "blue" sandstone associated with a minor proportion of black shale. In the southwest part of the quarry the sandstone is in fault contact with a steeply dipping dike of light-colored, altered rhyolite about 20 feet thick containing sparsely distributed crystals of quartz and pyrite in a matrix of finely crystalline feldspar. Spots of brownish calcite $\frac{1}{10}$ inch in diameter are abundant.

The principal product of the Hotaling quarry was crushed stone, but some dimension stone was produced also. Some of the volcanic rock may have been quarried for dimension stone in the early years of the operation (Goodyear, 1890). The dimension stone listed in the table of statistics for 1895, shown as "granite" in earlier tabulations, came from the Hotaling quarry, and it seems unlikely that sandstone would have been so classified. Among the buildings made of stone from the Hotaling quarry is the First Presbyterian Church, 5th and D Street, San Rafael. This church, as well as walls in the vicinity, is constructed of sandstone.

*Lagunitas Creek Gravel Deposit, Joslin Brothers.** Joslin Brothers, contractors, of Point Reyes Station have leased a gravel deposit on Lagunitas Creek that belongs to J. S. Burdell of Petaluma. The deposit is at the confluence of Lagunitas Creek and Arroyo Nicasio two miles west of Point Reyes Station. Aggregates for all purposes are produced.

Beginning in 1939 the Marin Gravel Company produced aggregates at this locality and also operated a crushed stone quarry on the southwest slope of Black Mountain, a short distance away. In 1953 the Marin Gravel Company closed the Lagunitas Creek plant and moved most of the equipment to a site on Burdell Mountain near Novato which is described in another section of this report. Joslin Brothers are producing gravel only and have not reopened the quarry.

The deposit consists of rounded creek gravel containing a relatively small proportion of 2 and 3 inch material. Perhaps half of the pebbles are composed of sandstone and the rest of chert and greenstone.

The gravel is recovered from the creek bed with a dragline scraper and transferred to the plant with an inclined belt conveyor. By moving the tail block, a considerable sector can be covered.

The plant consists of a four section revolving stone screen compounded at the feed end, that is, it has a finer screen mounted outside of and concentric to the first section. The gravel is washed in the screen with water pumped from the creek. As the gravel passes over successively coarser sections of the screen, the several sizes are screened out and stored in wooden bins. A drag chain classifier recovers sand from the material that passes through the finest screen, and a portion of this sand is screened with a small wet trommel. A second drag classifier recovers additional sand from the trommel undersize, and the silt laden overflows from the two classifiers are discarded.

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* Plant visit July 27, 1954.

McNear Point Quarry, Basalt Rock Company (Nordberg, 1950) *. Since 1945 the Basalt Rock Company, whose main office is at Eighth and River Streets, Napa, has leased the McNear Point quarry at Point San Pedro which forms the west side of San Pablo Strait. Initially the only product was jetty stone, but a secondary crushing plant for the preparation of crushed stone was added in 1952. John Meloni is superintendent of the McNear Point quarry.

The McNear Point operation consists of two quarries that were opened many years ago as separate operations. The more southwesterly can be traced back to the Jordan quarry of Dennis Jordan who began production in 1876. The Jordan quarry was later operated by the San Francisco Bay Improvement Company, but was acquired by the San Francisco Quarries Company early in the 20th century.

The more northeasterly quarry, originally called the Bull quarry, was opened by Bull and Gossard in 1904. G. P. and C. A. Wetmore operated it for a time, but by 1914 it had passed into the hands of the Daniel Contracting Company. Some time after World War I the Daniel Contracting Company took over the San Francisco Quarries Company operation also. In the following years a large plant was built that produced a very substantial tonnage of crushed and broken stone. Equipment in the mid 1920's included three stiff-leg derricks, two traveling cranes, four power shovels, eight locomotives, 77 dump and flat cars,

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* Plant visit June 10, 1954.

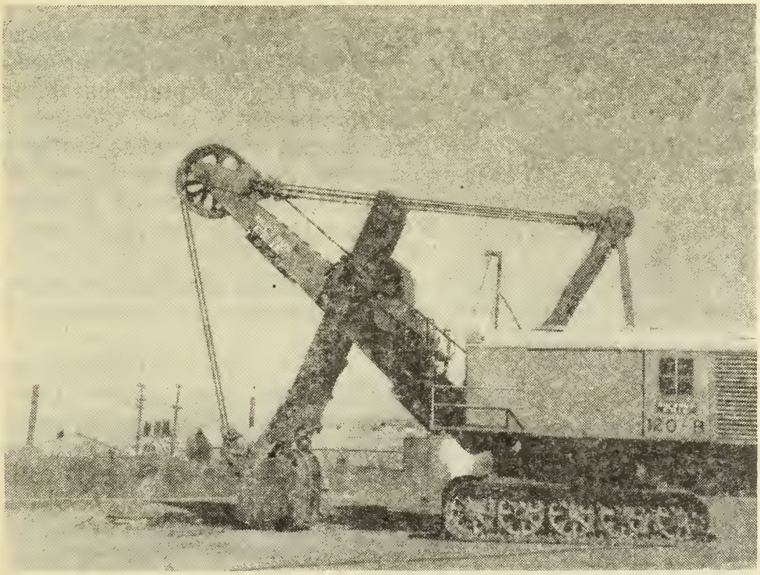

FIGURE 12. Electric shovel, McNear Point quarry, Basalt Rock Company. Blue Franciscan sandstone is quarried for aggregates and jetty stone.

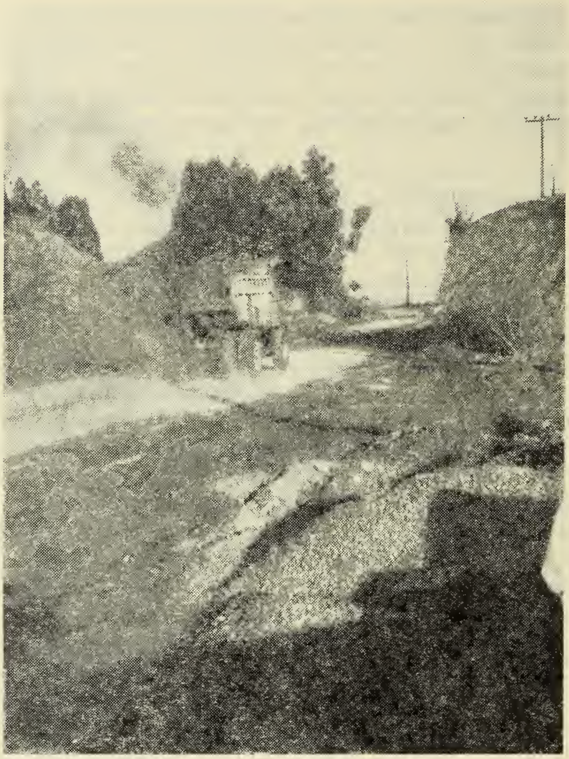

Figure 13. Hauling rock, McNear Point quarry, Basalt Rock Company. Euclid end-dump trucks bring the rock from the quarry face to the primary crusher.

and a preparation plant containing a 48 inch by 60 inch jaw crusher and a number 8 McCully gyratory crusher in addition to other crushers. Production continued until World War II. This plant has been dismantled, and scarcely a trace of it remains.

A third and apparently but little worked quarry exists southwest of the Jordan quarry. Known at one time as the Marin quarry, it was operated by Gray Brothers about 1905 and later by the Western Development Syndicate. The San Francisco Quarries Company leased it in January 1914.

Until 1952 when the Basalt Rock Company installed its secondary crushing plant, practically the entire output from the quarries on Point San Pedro was shipped by barge.

The quarries have been opened in a hard ''blue'' sandstone member of the Franciscan group similar to that which occurs at Greenbrae. The general strike of the rocks is northeasterly with northwest dips. To the southwest the blue rock apparently passes under San Rafael Bay southeast of the McNear Brick Company plant. All the exposed rocks are cut by small faults, and many of the fractures are filled with calcite veinlets as much as $\frac{1}{8}$ inch thick.

The more northeasterly of the two principal quarries is bounded on the northeast by a fault that separates the sandstone from the shale

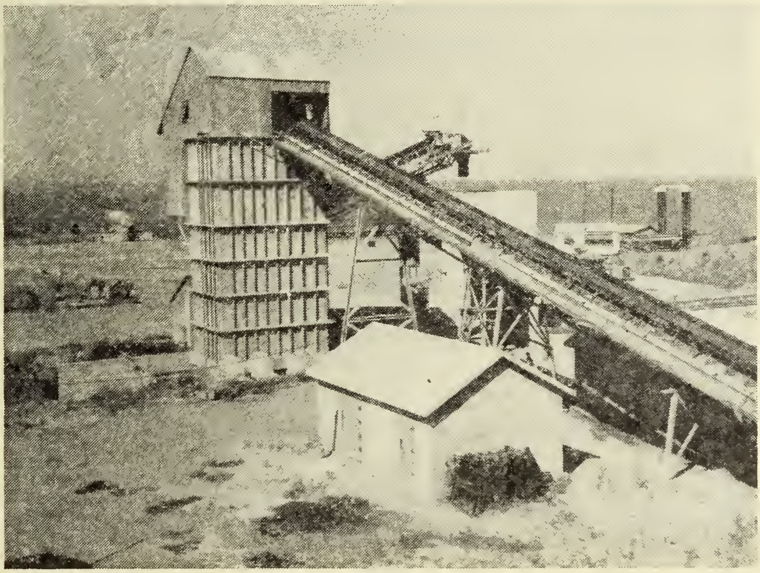

FIGURE 14. Primary crushing plant, McNear Point quarry, Basalt Rock Company. Quarry run rock is reduced with a Traylor Bulldog 48-inch by 60-inch jaw crusher. Minus 3- to 4-inch material is screened out, and the screen oversize is shipped for jetty stone.

quarried by the McNear Brick Company and the L. P. McNear Brick Company. The shale deposits are described in another section of this report. On the southwest side of the fault some black shale that is exposed in the quarry face appears to have been squeezed into its present position. Similar inclusions of shale occur throughout the ''blue'' sandstone but are less numerous than at the Greenbrae quarry. Between the northeast quarry and the southwest quarry lies soft, brownish sandstone typical of the Franciscan group. The southwest quarry is bounded on the southwest by black shale.

At present production is from the southwest quarry. Two benches have been developed in the high northeast portion of the face, but only one in the remainder of the quarry where the face is lower. Bucyrus-Erie electric churn drills are used to drill 9 inch diameter holes spaced

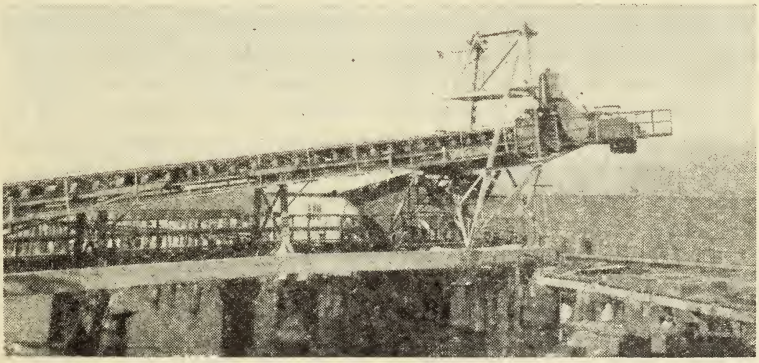

FIGURE 15. Belt for loading barges with jetty stone, McNear Point quarry, Basalt Rock Company.

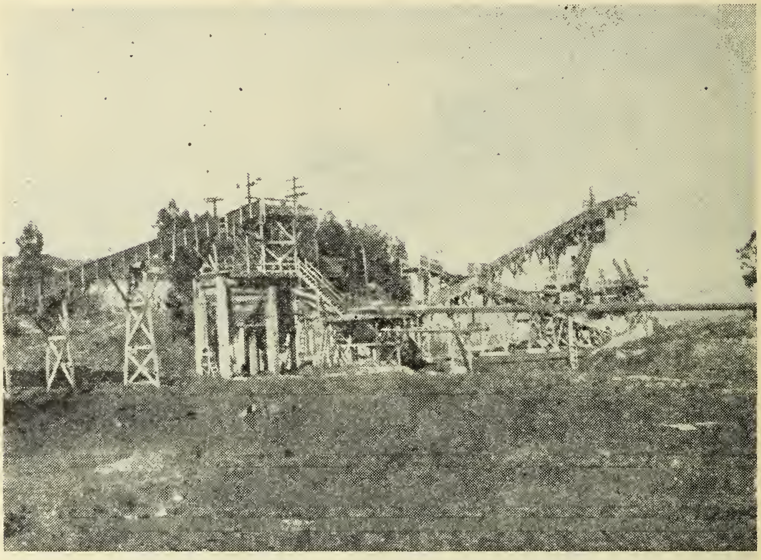

FIGURE 16. Secondary crushing and screening plant, McNear Point quarry, Basalt Rock Company. Fines screened from jetty stone in the primary crushing plant are recrushed and wet screened (left); then sized with dry screens (right).

10 feet apart and far enough back from the face to provide 40 to 50 feet of burden at the toe. As much as 15 tons of explosive in 10 to 14 holes have been detonated simultaneously with primacord and electric blasting caps. Delay caps are not used. Secondary drilling is done with jackhammers.

A 4½ cubic yard 120-B Bucyrus-Erie electric shovel supplemented by a 2½ cubic yard shovel load the broken stone into 13 cubic yard Euclid end dump trucks. The primary crushing plant is about half a mile away between the face of the northeast quarry and the shore. Jetty stone is produced here and belt loaded onto barges. The plant includes a Traylor Bulldog 48 inch by 60 inch jaw crusher set at 7 to 12 inches and fed by a Traylor reciprocating feeder-grizzly. Fines, minus 3- or 4-inch material, are separated from the crusher product with a grizzly and a 4-foot by 8-foot double decked Seco vibrating screen. Stones that are too large for the crusher are set aside and shipped as required for face and cap stone. In the summer of 1954 Engineers' rock consisting of pieces weighing between 15 and 200 pounds was produced for use on the Sacramento River. In order to obtain 1000 tons of Engineers' rock 2500 tons of fines are screened out. The plant's capacity of Engineers' rock is 250 tons per hour and of crusher run material, which includes the fines, 1000 tons per hour.

For a time the Basalt Rock Company produced only jetty stone at McNear Point, and the fines were stockpiled. A secondary crushing plant for the preparation of aggregates was built in 1952 near the southwest quarry, and additional equipment was installed in 1954. Four Euclid bottom dump trucks of 17 cubic yards capacity bring the fines from the primary crusher to the secondary crushing plant.

The plant consists of two sections. In the first the stone is washed with salt water on a 4 by 16-foot Symons double decked screen. Wash water is drawn from the bay near the northeast quarry, and the discharge containing the screen undersize is returned to the bay near the secondary crushing plant. If desired, sand can be recovered from the screen undersize with a drag classifier.

The coarse size from the wet screen is reduced with a 4-foot Symons cone crusher and, together with the middle size and the sand, is forwarded to the second section of the plant. A second 4- by 16-foot Symons double decked screen, run dry, separates the stone into sizes that are stored in bins. The coarsest size may be recrushed with a four foot Symons shorthead cone crusher and rescreened.

By means of Link-Belt apron feeders, the several sizes of crushed stone may be drawn from the bins onto a reversible horizontal belt for blending. When operated in one direction the belt discharges blended aggregate into trucks. In the other direction it leads to the slurry mixer, a revolving cylinder about 10 feet long, where a small amount of water is added. For some uses 5 to 7 percent of portland cement is added in the mixer, either with or without water.

Mount Tamalpais Cemetery Quarry. In the 1900-15 period the Mount Tamalpais Cemetery quarried some dimension stone and crushed stone for use in the cemetery. Since that time the cemetery grounds have been reduced in area, and the quarry is now on property belonging to James E. Gilchrist.

The quarry face is 75 feet long and about 25 feet high. In this opening two ledges of massive ''blue'' sandstone of the Franciscan group are exposed. The sandstone beds are separated by six inches of sheared black shale.

Tiburon Ridge Flagstone Deposit. Glaucophane schist has been quarried for flagstone from the west slope of Tiburon Ridge on property belonging to Thomas B. Deffeback. Tiburon Ridge is a well known glaucophane schist locality and one of the first in California to be studied. It was in this area that the mineral lawsonite was discovered (Ransome, 1895).

About 1952 Samuel Newsom of the Greenwood Tree, Mill Valley, quarried a few hundred tons of flagstone. The deposit lies about a quarter of a mile northwest of the summit above California Point and is within 100 yards of the paved road that leads from the San Francisco Bay shore to the summit of the ridge. The stone is a fine-grained, blue schist, with a pleasing sheen, that readily splits into thin slabs. Glaucophane schist has also been quarried at a lower elevation about 300 yards to the northwest of this locality.

Ceramic Industries

The ceramic industry is second in importance of the mineral industries of Marin County. High quality clays have not been found, but common clays are abundant. Sources of clay include both weathered and unweathered shale members of the Franciscan group and a residual type of clay derived from the weathering of shale.

Today the industry is represented only by the closely associated McNear Brick Company and L. P. McNear Brick Company at McNear Point which produce common brick and the lightweight aggregate Haydite. In the early years of the twentieth century, however, the Patent

Brick Company and the Remillard Brick Company also had brick yards in Marin County.

The plant of the Patent Brick Company, established in 1870, was at Gallinas Station; and residual clay was obtained from the nearby hills. Prior to 1904 brick were shaped by the soft mud process (Calif. Min. Bur., 1906, pp. 234, 236) and burned in three Hoffman kilns. One of the Hoffman kilns is thought to have been the first installed in the United States (Bradley, 1916, p. 248). In 1904 the plant was rebuilt to use the stiff mud process, and a circular oil fired kiln was added in which pressed brick were burned. The plant was last operated in 1909, although sales of brick from stock continued for several years. From 1923 to 1925 the Hidecker Brick Company of Oakland crushed some of the waste brick for use in the manufacture of roofing tile, and in 1924 the Hidecker Brick Company also crushed some "green rock" in Marin County for the same purpose. The Patent Brick Company was dissolved and the plant dismantled before 1926. Today nothing remains but the ruins of two or three brick buildings.

The Remillard Brick Company built a plant at Greenbrae in 1891, but there may well have been a brick yard at the same site earlier. Clay and shale were obtained from a pit just north of the plant and made into common brick by the soft mud process. This plant had a single Hoffman kiln, the ruins of which may be seen just east of the Hutchinson Company's quarry. The brick yard was closed at the end of 1913 and never operated again. In 1926 Louis Sbarbori leased the property with the intention of manufacturing floor tile. This enterprise seems not to have taken root, and there is no record of production.

*McNear Brick Company.** The McNear Brick Company produces the lightweight aggregate Haydite and lightweight concrete building blocks at McNear Point 4 miles east of San Rafael. William Thomas is Manager. The building block plant is described in another section of this report.

The McNear Brick Company and its predecessor the Fortin Brick Company produced common brick at this locality from at least as early as the 1880's until 1932. In 1947 the brick yard, described elsewhere in this report, was reopened by the L. P. McNear Brick Company, a separate, but closely associated organization. The parent company began producing Haydite in the early 1930's in order to broaden its market for clay products.

Haydite is a lightweight aggregate prepared by heating certain shales in a rotary kiln to incipient fusion, approximately 2000° F. Gases produced vesiculate the shale; and the kiln product, after cooling, is crushed and sized. The particles produced in this way are angular and have no glazed surface.

The raw material is shale of the Franciscan group that crops out on the east side of San Pedro Hill just north of the Basalt Rock Company's McNear Point quarry. The shale beds are contorted, shattered, and in fault contact with hard "blue" sandstone to the south. The strike is east to northeast, and dips range from vertical close to the fault to 45 degrees northwest a few hundred yards to the north. From experience the operator has learned to distinguish in the field shales that vesiculate in the kiln from those that do not, but no chemical or mineralogic

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* Plant visit May 24, 1954.

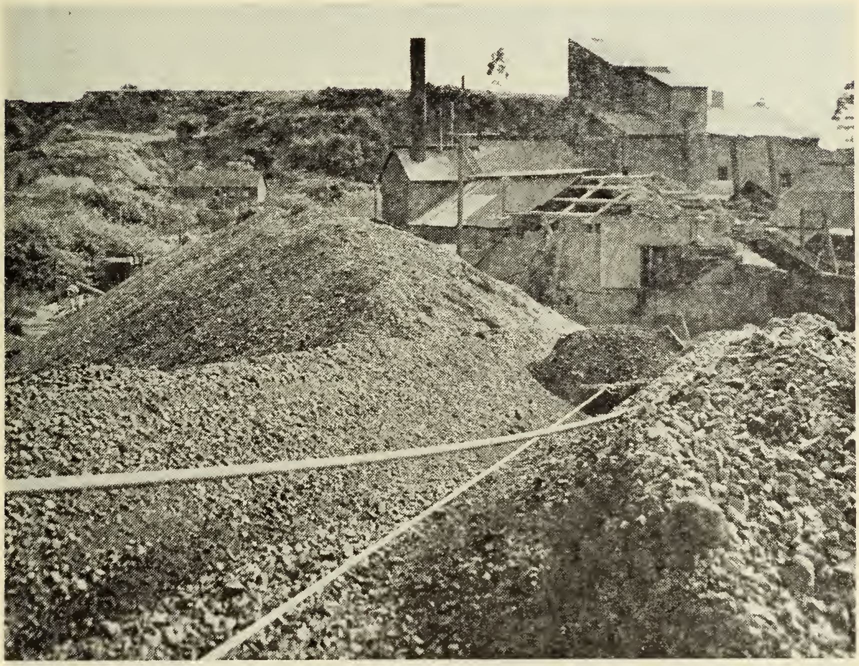

FIGURE 17. Expanded shale being drawn toward crusher from expanding plant, McNear Brick Company. *Photo by Richard C. Clark, Clay, Brick, and Tile Association.*

criteria have been discovered. Close to the fault lies hard, black, slatelike shale that, when freshly quarried, does not vesiculate. The black shale, however, is satisfactory kiln feed after a period of weathering in the muck pile. Brown shale that overlies the black shale is the most satisfactory and vesiculates at a temperature 200° F. lower than the black shale. The weathered outcrops of neither the brown shale nor the black are suitable feed for the Haydite plant, but common brick can be made from the weathered shale. On the west side of San Pedro Hill the quarrying of clay for brick has exposed bed rock over a wide area. Shale occurs there, but none suitable for the Haydite plant has been found.

Unweathered shale for the Haydite plant is obtained from a large pit just north of the Basalt Rock Company quarry. Several benches have been developed, using a power shovel to load the shale into trucks; and blasting is seldom necessary. The overburden of weathered shale that covers the unweathered shale is usually stripped off by the L. P. McNear Brick Company for making brick.

Shale is trucked to the plant which is housed in the wooden structure where raw material for brick is prepared. The unweathered shale for Haydite is reduced to minus 3 inches with a single-roll crusher and elevated to a storage bin from which it is fed to the kilns. The plant contains four oil-fired rotary kilns, two 80 feet long and two about 50 feet long. In the summer of 1954 only one of the 80 foot kilns was in operation, and the two shorter kilns were in disrepair. The kiln charge reaches a temperature of from 2150 to 2250° F. and the hot discharge is transported to a stock pile with a pan conveyor.

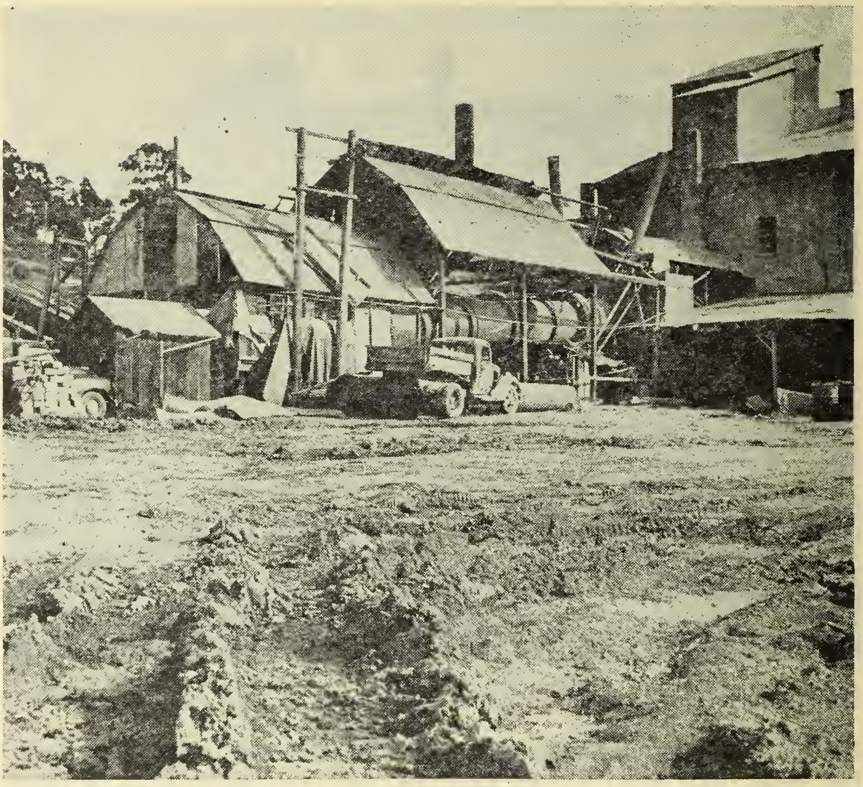

FIGURE 18. Rotary kiln for expanding shale, McNear Brick Company. *Photo by Richard C. Clark, Clay, Brick, and Tile Association.*

After the expanded shale has cooled, a dragline scraper transfers it to a crushing and screening plant constructed of steel and reinforced concrete. The feed first passes over a grizzly the oversize from which is reduced with a Kue Ken jaw crusher. The combined crusher product and grizzly undersize are elevated to a double decked vibrating screen mounted over truck loading bins. A belt is provided for returning a portion of the coarsest size to a roll crusher, the product from which is returned to the screen. Three sizes of finished Haydite are stocked in the open, $\frac{3}{4}$ inch, $\frac{3}{8}$ inch, and 16 mesh. An adjoining building contains equipment for placing Haydite in paper bags.

*L. P. McNear Brick Company.** Since 1947 the brick yard of the McNear Brick Company at McNear Point has been leased to L. P. McNear. L. J. Migliore is Superintendent.

The present plant was built by the McNear Brick Company about 1900. An older plant, that of the Fortin Brick Company, burned a clay soil in nine ''ordinary outside kilns'' (Calif. Min. Bur., 1894, p. 382), presumably wood fired field kilns. In 1893, 140 men were employed and 12 million brick produced.

The McNear Brick Company built a Hoffman kiln and installed equipment to process a mixture of shale, plastic clay, and sandstone.

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* Plant visits May 24 and June 10, 1954.

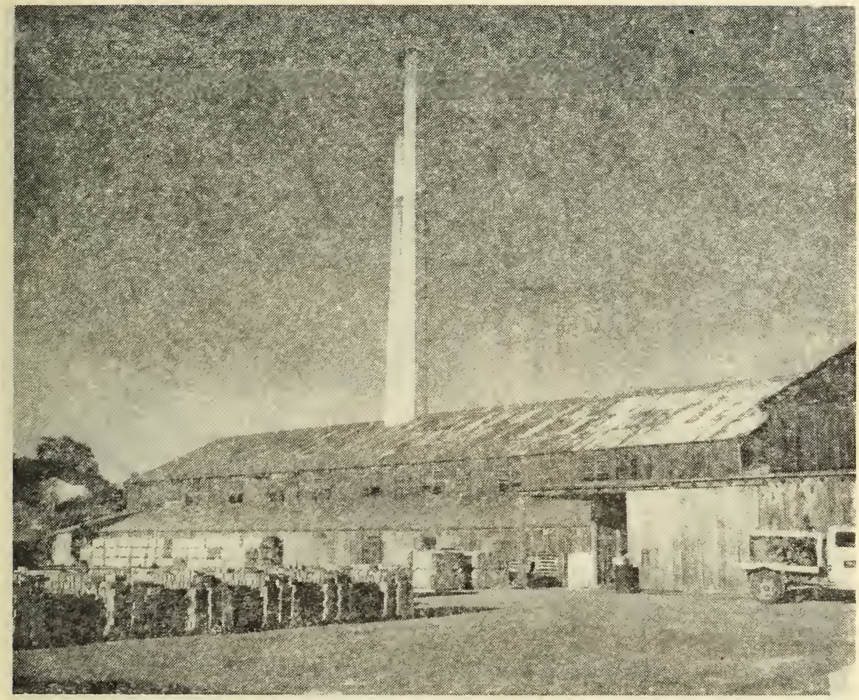

FIGURE 19. Hoffman kiln, L. P. McNear Brick Company. Green brick made from clay shale of the Franciscan group are fired in one of two Hoffman continuous coal-fired kilns. *Photo by Mort D. Turner.*

The plant in 1904 included also two oil-fired, five-compartment, down-draft kilns that may well have been built some years before the Hoffman kiln. The down-draft kilns have long been dismantled, but the stack that served them still stands. A second Hoffman kiln was added in 1906. Raw material was scraped from a bank of the west side of San Pedro Hill.

The plant was operated almost continuously until 1932 when lack of a market for brick forced its shut down. About this time the McNear Brick Company began producing Haydite; and in 1947, when brick was again in demand, the brick yard was leased to L. P. McNear.

Today the principal raw material for the brick plant is the weathered shale overburden obtained from the quarry on the east side of San Pedro Hill that supplies the Haydite plant. This quarry is described in another section of this report. Although the brick plant could use the unweathered shale, it is convenient to take the weathered shale that must be moved in order to obtain the Haydite plant feed. Good brick can be made from the clay overburden formerly used but the supply is limited. Because the clay is more plastic than the weathered shale, up to 10 percent is used to improve the plasticity of the mix and the color of the brick. A greater proportion of clay would cause excessive shrinkage.

Raw material is trucked to the plant and dumped directly into a dry pan where it is crushed by revolving chasers until it passes through slots in the pan. The ground material is elevated to a shaking screen

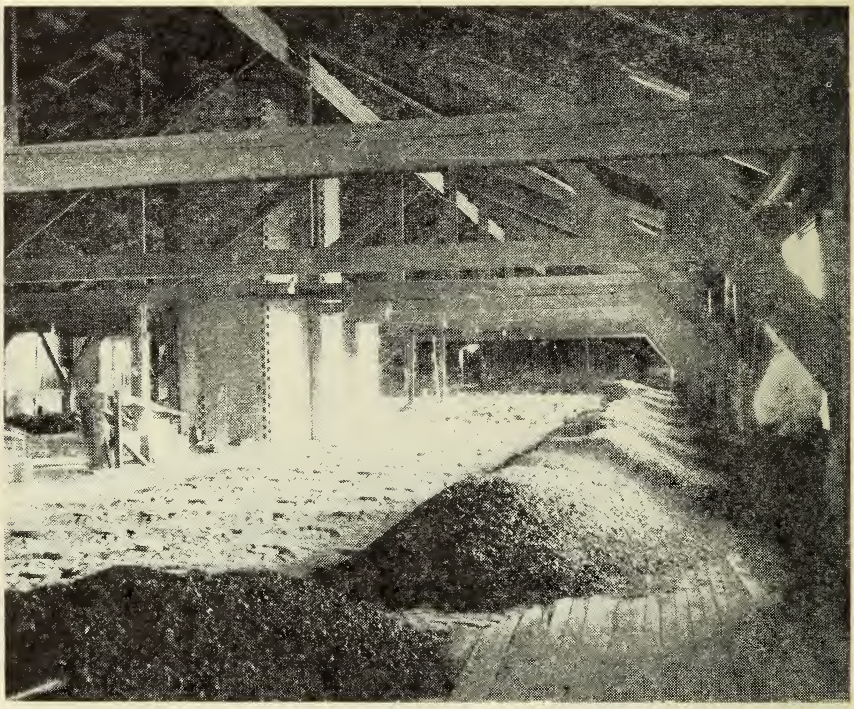

FIGURE 20. Top of Hoffman kiln, L. P. McNear Brick Company. Each roof hole in the fire zone receives about a pound of slack coal every 45 minutes. *Photo by Mort D. Turner.*

from which the oversize is returned to the dry pan or alternatively passed through a hammer mill before being reintroduced into the grinding circuit. Fines from the screen are stored in a bin.

Ground shale is pugged with water, and the stiff mixture, after passing through a vacuum de-airing machine, is extruded through a die. The de-airing machine, installed in 1953, has greatly improved the quality of the brick. The moving, extruded clay is cut into brick with a wire cutter with 18 wires that produces 17 brick at a time. The green brick are hand loaded on pallets and transferred with a fork lift truck to a car equipped with a hydraulic lift for placing the pallets in covered drying racks. From 25 to 30 days is required for drying in summer or 40 to 50 days in winter. In addition, covered storage is provided for a million dried brick.

The dried brick are fired in one of two Hoffman kilns, each having a nominal capacity of 30,000 brick per day. The Hoffman is a coal fired continuous kiln in which the firing zone moves, and the ware being burned remains in one position. Hoffman kilns were standard equipment 50 or more years ago, but have been largely superseded by the tunnel kiln, field kiln, or other types. Probably not more than half a dozen Hoffman kilns are in service in California today.

The Hoffman kiln consists of two parellel arched tunnels connected at the ends by semi-circular sections to form a continuous tunnel. Access is by means of arched openings about 10 feet apart in the outer wall. The kilns at the McNear plant are about 150 feet long, and the arched tunnels measure about 10 feet high by 10 feet wide. The number one kiln has eight openings on each side, three on one end, and two on the other, making 21 in all. The number two kiln, which lacks the odd end opening, has a total of 20.

Between each pair of openings and close to the floor of the tunnel are flues that lead inward to a centrally located stack. Each flue is equipped with a damper controlled from the flat top of the kiln. In the roof of the tunnel are 6-inch diameter holes equipped with covers for the introduction of coal which is conveniently stacked on top of the kiln. The holes are arranged in rows of five transverse to the tunnel axis, and the rows are 3 feet apart.

In operation the fire zone, which is 18 rows long is advanced at the rate of four to six rows per 24 hours and completes the circuit of the kiln in 16 calendar days. Each roof hole in the firing zone receives about a pound of coal every 45 minutes. The consumption of fuel is 90 tons of slack Utah coal per kiln per month. The progress of the burn is judged by measuring the shrinkage of the brick with a graduated rod inserted through one of the roof holes. Periodically the firing zone is advanced by ceasing to fire one row of holes at the rear and adding one row at the front. The temperature immediately in front of the firing zone is hot enough to ignite the added coal.

Ahead of the firing zone are green brick that are pre-heated by the hot combustion gases, while behind it are cooling, burned brick that

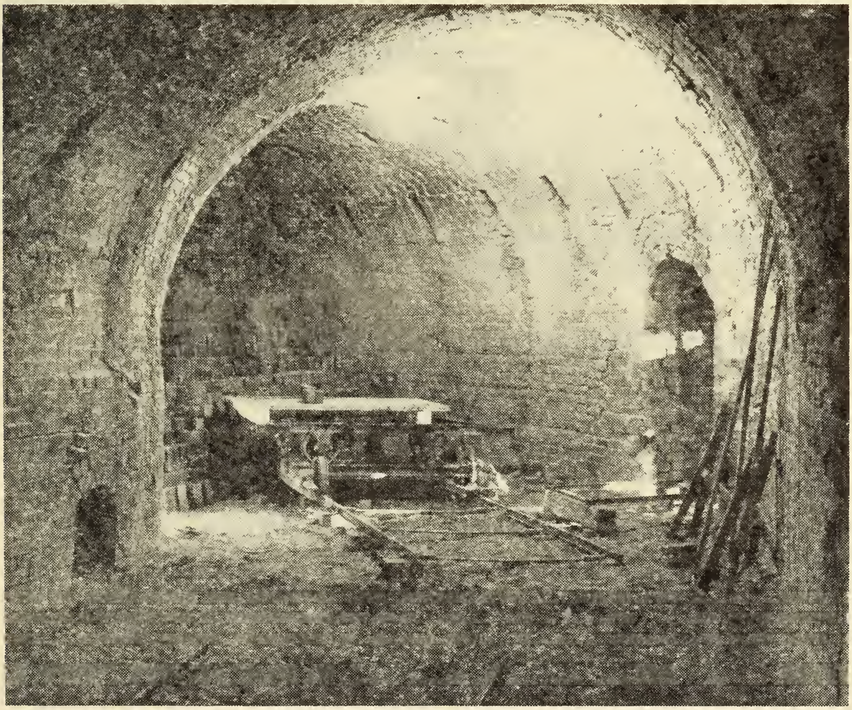

FIGURE 21. Interior of Hoffman kiln, L. P. McNear Brick Company. Access is by means of arched openings (right) in the outer wall. Between each pair of openings are flues (left) that lead to the centrally located stack. Men enter the open section of the kiln, farthest from the fire zone, to remove the burned brick and put in green brick. *Photo by Mort D. Turner.*

preheat the combustion air. All of the doorways except the two or three farthest from the fire are temporarily bricked up and tightly sealed with clay, and all the dampers are closed except those farthest from the fire. A paper blank sealed across the tunnel between the open door ways and the open flues forces the draft to pass through the burned brick to the fire and through the green brick to the stack.

Men enter the open section of the kiln to remove the cooled, burned brick from behind the fire and stack green brick ahead of the fire. The brick are loosely but carefully stacked to permit the free circulation of gases. To provide space for the fuel, poles are temporarily inserted through the roof holes, and the brick are stacked around them.

After the newly placed green brick have advanced about 10 feet from the paper blank, the open doorway is blocked and another is opened toward the fire to provide access to the completed brick. A new paper blank is fitted across the end of the stack of green brick, and the old blank is burned out by igniting oil poured on it through the roof holes. The dampers in the newly loaded section are then opened and those behind it closed, thus connecting the new section into the live portion of the kiln.

The firing up of an idle kiln is a lengthy and fairly complex operation. In the latter part of May 1954 the number two kiln, idle since 1952, was fired up and the first brick obtained in about two weeks. Wood fires are first burned in the empty kiln to dry the brick-work and floor thoroughly. Brick, often burned brick, are then stacked in the kiln, and a temporary wall is built in the open section some feet from the stacked brick. A fire is built behind the wall and maintained until the brick beyond are hot enough to ignite coal dropped through the charging holes. Formerly the fire was of wood fed through openings in the temporary wall, but today oil burners may be used. In some cases it may be necessary to run the fire zone completely around the kiln one or more times before the starting brick can be removed and green brick put in.

Brick taken from the kiln may be shipped at once or stockpiled. Only one type of common brick is produced at the L. P. McNear plant.

Coal

Prior to 1890, before petroleum was widely used, some prospecting for coal was carried out in Marin County. Thin lignite seams associated with shale members of the Franciscan group and of the Merced formation have been found at several places, but none are commercial.

On the former Murray Ranch, now the property of George Rogers, prospecting for coal was carried out; but the author has been unable to find out when the work was done. On a tributary of Halleck Creek 2.3 miles northeast of Nicasio a tunnel has been driven southward in sandstone. Outcrops on the grassy hillside above the tunnel are scarce, and no evidence of coal was found. Joe Reading of Schellville, who at one time owned the Murray Ranch, believes that the tunnel actually was driven in a search for coal.

At the Escalle quarry a thin seam of impure lignite was reported, (Bradley, 1916, p. 254). The Escalle quarry, 0.8 miles from Larkspur on the road to San Anselmo, is a small quarry active before 1914 from which crushed stone was produced from a ''blue'' sandstone member of the Franciscan group.

Specimens of lignite have also been taken near Tomales Bay (Bradley, 1916, p. 248) and Bolinas (Parker, 1893, p. 214).

Gems

Jasper is abundant in Marin County, and the first confirmed discovery of nephrite north of San Francisco Bay was in Marin County (Chesterman, 1951). The production of gem materials, however, has been small, although the records show that some jasper was produced in 1935.

Jasper

The jasper recorded in the Marin County production table was obtained from the excavation for the north pier of the Golden Gate Bridge and the nearby shore. Much of it was taken by Francis J. Sperisen, Lapidary, of San Francisco with the intention of preparing cabochons from it. Two varieties were obtained, multicolored rainbow jasper, and a mixture of red, brown, and green jasper.

Unfortunately the stone has been fractured and recemented with calcite, and it tends to break along these planes of weakness during the polishing. Sperisen presented most of the stock to the California Academy of Sciences and the Division of Mines where it is on display.

Nephrite

Probably the first discovery of nephrite in California north of San Francisco Bay was made approximately 1 mile southwest of Union School on the M. Vonsen Ranch. The deposit has been described in considerable detail by Chesterman (1951). Nephrite is associated with serpentine on the east slope of Massa Hill. The serpentine crops out on the middle slopes completely around the hill, and Franciscan schist occurs on the summit and upper slopes. Sandstone underlies the lower slopes below the serpentine. The nephrite is in the form of veins and lenses in the serpentine close to the schist contact. The nephrite bodies are a maximum of 6 inches thick and up to 5 feet long. In color the nephrite ranges from pale to dark bluish green. Both professional and amateur lapidarists have produced pleasing cabochons from the darker stone.

Limestone

Several small limestone deposits are known in Marin County, and burned lime was produced on a small scale in the 19th century. There has been, however, no recorded production. The deposits are of two types, the roof pendants of metamorphosed sediments of the Sur series that are intruded by quartz diorite on the Point Reyes Peninsula, and limestone members of the Franciscan group.

Point Reyes Deposits. Some long idle pits and cuts have been opened in Sur series limestone on the property of J. W. Lockhart near the Laguna Ranch road about $\frac{3}{4}$ mile from the Sir Francis Drake Highway. Within 100 yards of the Sir Francis Drake Highway and just off the Laguna Ranch road are the ruins of two small kilns in which the limestone was probably burned. In addition to the scattered openings in limestone on the Lockhart property, there are small detached outcrops as well as boulders of limestone separated by soil derived from the weathering of granitic rock. Limestone can be traced northward for perhaps half a mile, but to the south for not more than 200

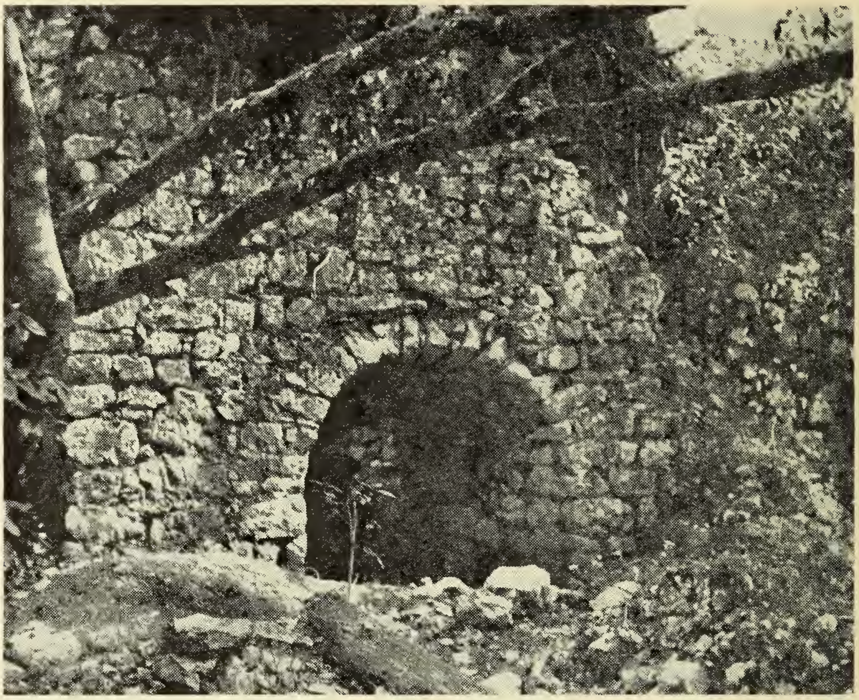

FIGURE 22. One of the old lime kilns at Olema. *Photo by Mary Rae Hill.*

yards. It seems likely that the limestone on the Lockhart property is in the form of detached pods intruded by and intermixed with quartz diorite rather than in a single continuous body.

The limestone itself is a coarsely crystalline white material lightly stained with iron. Parts, at least, are of high purity as the following analyses show. There is no record of the exact location of the samples nor of the manner in which they were taken (Eckel, 1933, p. 353, Table 1.).

No.	SiO_2	Al_2O_3	Fe_2O_3	$CaCO_3$	CaO	$MgCO_3$	MgO	CO_2
7	1.66	0.44	0.20	96.60	n.d.	0.75	n.d.	n.d.
8	2.26	0.55	0.25	95.48	n.d.	1.10	n.d.	n.d.
9	2.3	0.76	incl.	96.0	53.8	n.d.	0.35	42.7
10	1.3	0.3	incl.	97.0	54.32	n.d.	1.25	42.68

No. 7 Old quarry near Trout Farm
No. 8, 9 Lockhart tract near Inverness Park
No. 10 Near Inverness Park

Small bodies of crystalline limestone are probably more widely distributed on the west shore of Tomales Bay than the geologic map of Weaver (Weaver, 1949b, Plate 9) suggests. Coarsely crystalline white limestone with associated scheelite occurs between Willow Point and Point Reyes Hill on the E. A. Bender property, while gray limestone is present at the Noren tungsten prospect a quarter of a mile west of the junction of the Bear Valley road and the Sir Francis Drake Highway.

Franciscan Limestone. Although in Santa Clara County the Calera limestone member of the Franciscan group is an important source of limestone, the Franciscan group in Marin County contains only small limestone lenses. The deposit at "Russian Kilns" south of Olema is typical. Another small lens occurs on State Highway 1 between Muir Beach and Stinson Beach.

Among the things of historic interest in Marin County are the three old stone lime kilns on the bank of Olema Creek 4½ miles south of Olema and just west of State Highway 1. The kilns are on the property of Sam Smoot of Petaluma. The apparent antiquity of the structures as well as the presence of trees growing in them has led to the supposition that the kilns are of Russian or Spanish origin. It is now known, however, that the kilns were built by Americans in the early 1850's. On the bank immediately above the kilns a small quarry has been opened. The deposit consists of well bedded, steeply dipping, fine-grained gray to pink Franciscan limestone that contains chert in places. Analyses of two specimens follow (Eckel, 1933, p. 358, Table 2).

	No. 7	*No. 9*
SiO_2	1.1	1.90
Al_2O_3	0.68	0.76
Fe_2O_3	incl.	0.20
$CaCO_3$	97.8	96.74
CaO	54.8	n.d.
$MgCO_3$	n.d.	0.33
MgO	tr.	n.d.
CO_2	43.2	n.d.

Manganese

In Marin County a number of manganese deposits exist that are typical of those found associated with Franciscan chert throughout the Coast Ranges. Two have been productive, the Knutte deposit near Novato, active during World War II, and the Sausalito Point deposit from which manganese ore was mined in 1882.

Manganese deposits of the Franciscan type have been discussed by Trask, Wilson, and Simons (1943) and by Taliaferro and Hudson (1943). Manganese minerals are associated with the lenticular chert bodies of the Franciscan group, particularly with massive white or green chert. Typically the deposits are pancake shaped, and the maximum diameter in few cases exceeds 200 feet.

The most abundant primary minerals are rhodochrosite ($MnCO_3$) and manganiferous opal, both of which are probably syngenetic. Almost always the ore minerals are secondary minerals formed by the oxidation of the primary minerals. Oxidation commonly extends to depths of as much as 200 feet, although the primary minerals are found at or within 10 feet of the surface in some deposits. The manganese oxide ores are of two types, the sooty black pyrolusite (MnO_2) and the harder psilomelane, an impure hydrous manganese oxide with small amounts of barium. Deposits grade from material containing 55 percent or more of manganese to chert containing mere films of manganese oxide in fractures.

Knutte Deposit. The Knutte deposit is approximately 1 mile south of Novato a short distance west of South Novato Boulevard. During World War II it was leased by L. R. Knutte, and from 1942 to 1945 inclusive a few car loads of ore were mined from two small open pits. With the termination of the Federal Government's purchasing program in 1945 the deposit was closed. The property now belongs to Louis J. Glicksberg of San Francisco.

Sooty black manganese oxides are associated with nearly horizontal chert beds that crop out near the summit of a small hill. The chert is enclosed in sandstone of the Franciscan group. At the northeast open cut, the smaller of the two, the face is about 25 feet high and 300 feet long and has been driven into the hill about 100 feet. Most of the face is concealed by grass-covered, slumped material except at the west end where thin-bedded, manganiferous chert crops out. The chert is interbedded with sandstone and dips eastward at a low angle. Near the cut are some boulders of mixed manganese oxides and silica that may be low grade material rejected during mining.

At the southwest open cut the manganese ore occurs near the upper contact of a chert lens that may be a portion of the chert body exposed in the northeast open cut. The southwest flank of the hill has been excavated over an area of about an acre to a maximum depth of 30 feet. The floor of this excavation is barren chert; little ore remains. Some massive chert in the ore horizon contains up to 25 percent manganese oxides, and this material is enclosed in thin-bedded chert of still lower manganese content. In the area between the two workings no excavations have been made, and no evidence of ore was observed.

Mazza Deposit. During World War I, M. Vonsen of Petaluma developed a manganese deposit on the Mazza Ranch, but no shipments were made. The deposit is 2½ miles southeast of Union School, a locality on the Petaluma-Point Reyes Road just south of the Marin County boundary.

A pit about 30 feet in diameter has been excavated, but it has been nearly filled with material bulldozed from a nearby trail. Some thin-bedded chert is present in the pit wall, and the dump material consists largely of massive chert stained with manganese. Davis and Hudson (Trask, P. D. and others, 1950, p. 106) reported that the deposit consists of a body of mixed manganese carbonate and silica at least 15 feet thick. Small amounts of cinnabar and pyrite are present. The proportion of silica is so high that the production of manganese ore seems unlikely.

Sausalito Point Deposit. About 1882 a small amount of manganese ore was mined near Sausalito and used as a flux in a custom smelter at Sausalito. Penrose (1891) states that the ore was taken "near the summit of one of the mountains" just west of Sausalito. The deposit consisted of pockets of manganese oxide 1 foot to 3 feet in diameter associated with chert.

Mercury

In many places in the Coast Ranges of California cinnabar is associated with serpentine and its alteration product silica-carbonate rock. Both serpentine and silica-carbonate rock are abundant in Marin County, but only one deposit of cinnabar has been discovered.

Gambonini Deposit. In 1945 cinnabar was discovered on the M. Gambonini Ranch on Salmon Creek approximately 6 miles east of Marshall. The discovery was made by Ferdinand Stover who found cinnabar on the shore. By panning, he traced it up Walker Creek and its tributary Salmon Creek to the apparent source about half a mile northwest of the Gambonini Ranch house.

The abundance of cinnabar float in Salmon Creek and its tributaries and the distance that it had migrated gave rise to hopes that a major cinnabar deposit was in the vicinity. Stover leased the deposit from Gambonini, the property owner, and shortly afterwards the Cordero Mining Company took a leasing option on it from Stover. Between that time and 1948 Cordero Mining Company spent $40,000 to $50,000 in exploring the property. Pods of rich ore were found in several places, but all proved to be shallow.

The ore occurs as films of fine grained cinnabar in fractured Franciscan sandstone and shale. One pod of ore occurs near a flat saddle between the main hill mass and a spur to the south. This pod was explored with a short tunnel. Some trenching was done at a higher elevation and north of the saddle on a second pod which contained ore of 30 to 35 pounds per ton grade. In addition the Cordero Mining Company sank a shallow shaft on another rich but superficial pod on an adjoining property. Samuel H. Williston of the Cordero Mining Company feels that these occurrences of cinnabar may be lower extremities of a large orebody that has been almost entirely removed by erosion. The length of the ''tail'' of cinnabar float in Salmon and Walker Creeks is supporting evidence.

Mineral Water

The older literature on the mineral resources of Marin County (Watts 1893: 251; Waring 1915; Bradley 1916: 249, 250) lists a number of mineral springs and wells. The Tamalpais Mineral Well, however, is the only one from which production has been recorded. From 1931 to approximately 1952 the Purity Spring Water Company reported production of spring water from Sausalito. This water, however, was unmineralized and sold for table water; and it should not properly be classified as mineral water.

Tamalpais Mineral Well. The Tamalpais Mineral well was sunk in 1903 at First and Hayes Streets, San Rafael. It was 6 feet in diameter and 26 feet deep, and it yielded a mildly saline uncarbonated water. The following is a partial analysis (Waring 1915, p. 308).

	Parts per million
Na	79
Ca+Mg	138
SO_4	small
Cl	121
CO_3	207
	545

From 1908 to 1930 inclusive it was bottled and sold by Borello Brothers.

Petroleum

The Point Reyes Peninsula contains the middle to upper Miocene marine sediments of the Monterey formation that are important source beds of petroleum in other parts of California. Gas seeps and natural asphalt occur near Bolinas and Duxbury Point, but petroleum in commercial amounts has not yet been found. In the San Francisco-Marin block, the Franciscan group, which is the predominant formation, is an unlikely source of petroleum.

On the Point Reyes Peninsula the base of the Monterey formation is exposed on Inverness Ridge and at Point Reyes. In the northern two-thirds of the area the sediments are but one or two thousand feet thick, but near Bolinas their thickness is probably several times as great. The Monterey formation consists of siliceous and clay shale with a minor proportion of sandstone. These rocks have been folded into a series of northwest-trending anticlines and synclines. Between Bolinas and Bolinas Point the coast runs transversely to the regional trend, and an anticlinal axis is exposed in the sea cliff half a mile west of Bolinas. This structure is cut off on the east by the San Andreas fault zone, and there is no surface evidence of closure to the northwest. Gas seeps, however, are evidence that petroleum does occur in the Bolinas area.

As long ago as 1904 three shallow wells were drilled near Duxbury Point. Known as the Garzolia Ranch or Duxbury Point wells, they were from 1800 to 2400 feet deep and encountered showings of heavy oil. In 1948 and 1949 L. M. Lockhart drilled well number R.C.A. 3-1 in the same area. With a total depth of 8409 feet, this well did not pass through the Miocene sediments. Tevis 1 was drilled by L. M. Lockhart in 1949 near Double Point about 5 miles to the northwest. It was later deepened to 6,587 feet by the Standard Oil Company of California and bottomed in sand and shale. The Standard Oil Company also drilled the 7,286 foot Robson 1, 2 miles northeast of Double Point and some shallow wells on the Mendoza property north of Point Reyes during 1951 and 1952.

Two shallow test holes have been drilled on the Morris Ranch about half a mile south of Point Reyes Station. The first, financed by Peter Morris, was drilled in 1951 or 1952. The second, called PM Oil Company no. 1, was drilled by Peter Morris and a few associates in 1953 and 1954. Both holes were in the San Andreas fault zone and encountered difficult drilling conditions. The second hole was bottomed in the Franciscan group at 1,670 feet. The first encountered some gas, but the driller's log of the second reported only traces of oil.

Potash

The table of mineral production of Marin County lists potash among the minerals produced in 1922. The potash material was potash char with an equivalent K_2O content of 36 percent, and it was produced at Sausalito by the Mason By Product Company from a waste product of the American Distilling Company's Sausalito distillery.

Salt

Although the production of salt by the evaporation of sea water began in Alameda County as early as 1856 and is today a flourishing industry, only a small amount of salt has been produced in Marin County. Bradley (Bradley, 1916, p. 250) states that a solar salt works was in operation near San Rafael in 1867, and an old map dated in the 1870's in the possession of the Leslie Salt Company shows a small salt works in the northeastern portion of Richardson Bay. The production of 700 tons reported in 1902 may represent the output of several small plants. The only other recorded production is that of James Baumberger whose Golden Gate Salt Corporation was active in 1906. The location of the Baumberger plant has not been ascertained.

Although the need for increased salt capacity exists in the San Francisco area, it is not likely that a salt works in Marin County would be economically feasible. Salt marsh land forms a nearly ideal site for solar evaporation ponds, but with a maximum yield of 40 tons of salt per acre, a vast area must be in production. Small salt works of only 100 to 150 acres are in production today, but to obtain the maximum advantage from mechanized equipment, a single salt works should contain a minimum of 5,000 acres. The marshes along the bay shore of Marin county are in isolated tracts that total but a fraction of this area.

Tungsten

In 1950 or 1951 E. A. Bender discovered scheelite on his property in the area of granitic and metamorphic rocks south of Inverness on the northeast slope of Inverness Ridge. By chance a visitor had panned the gravel of the stream on the Bender property for gold, and soon afterwards Bender found an unfamiliar mineral which was identified as scheelite by the State Division of Mines. By panning he traced the scheelite to its source, a placer deposit that crossed the stream; and trenching later disclosed scheelite in place. Filled with enthusiasm, Bender was discussing his find one evening with a neighbor, Chester Noren. They discovered that the stream on the Noren property also contained scheelite, the source of which was subsequently located. Both properties have been prospected to a limited degree, and preparations for shipping concentrates from the Bender deposit are in an advanced stage.

The scheelite deposits of Inverness Ridge are contact metamorphic deposits associated with limestone and biotite schist roof pendants that have been intruded by quartz diorite. Contact metamorphic minerals other than scheelite are not abundant. Although this is the typical setting for scheelite in the Sierra Nevada province of California, the Bender deposit is the first confirmed discovery in the metamorphic rocks of the Coast Ranges.

*Bender Tungsten Deposit**. Scheelite-bearing alluvium as well as scheelite in place exist three-quarters of a mile west of Sir Francis Drake Highway on the banks of the stream that enters Tomales Bay at Willow Point. The property belongs to E. A. Bender. Bender reports a second but smaller occurrence of scheelite farther on the same stream on the east slope of Point Reyes Hill.

At the lower locality a northwest-trending strip of scheelite-bearing alluvium about 100 feet wide and containing up to one percent WO_3 crosses the stream. The limits of the alluvial deposit have not been found, either to the northwest or to the southeast.

Natural outcrops are scarce, but bedrock has been exposed in shallow excavations. A roof pendant composed of coarsely crystallized white limestone and biotite schist is in intrusive contact with quartz diorite. The limestone, which contains sparsely distributed flakes of graphite, lies on the east side of the roof pendant and schist is on the west side. The roof pendant is apparently elongated in a northeast direction because the limestone can be traced some distance southward in the bed of a small stream. The schist, according to Bender, persists northward at least as far as the stream divide, which marks the north boundary of the Bender property.

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* Visit September 28, 1954.

Scheelite in place is in the form of crystals a quarter of an inch to half an inch in size in the limestone. It has been found only on the north bank of the stream about 100 feet above the bed. In the stream bed as well as on the south bank the bedrock beneath the alluvial scheelite deposit is barren granitic rock.

Bender has developed the deposit in his spare time with the aid of one helper. It is planned initially to mine the alluvial material from the north bank, and a chute has been built for transferring the ore from the deposit to a bin near the stream bottom. The chute terminates at a fixed screen placed over the bin for the removal of coarse material. This screen is housed in a light tight structure so that waste can be picked out of the coarse material with the aid of an ultraviolet lamp. Having tested numerous beneficiation methods, Bender has started to construct a small mill. After being crushed to about ¼ inch the ore will be separated into three sizes with a hydraulic classfier. Scheelite will be recovered from the sized feed by tabling.

Noren Deposit. Scheelite occurs on the property of Chester R. Noren in a small stream valley a quarter of a mile east of the junction of the Bear Valley road and Sir Francis Drake Highway about a mile from Point Reyes Station. The scheelite is associated with a roof pendant of metamorphosed sediments that has been intruded by quartz diorite. The roof pendant, which is about 300 feet wide, consists of white, coarse-grained limestone, gray, fine-grained limestone, and biotite schist. Immediately upstream from the roof pendant quartz diorite is the only rock exposed, but Thaleur in a private report prepared for Noren states that a second body of limestone exists half a mile above the tungsten deposit.

Scheelite occurs on the west edge of the lower roof pendant as a replacement of gray limestone. Much of the limestone as well as the nearby granite is silicified and contains disseminated pyrite. Samples of scheelite have been collected that contain as much as 2 per cent WO_3.

In 1952 Knob Hill Mines Inc., 206 Sansome Street, San Francisco, leased the deposit. After a road was constructed and a limited amount of stripping had been completed, the lease was terminated.

Gold, Silver, Copper, and Lead

Gold, silver, copper, and lead, the traditional objectives of the prospector and products of the mining industry, are scarce in Marin County. The ore minerals of these metals, however, are not unknown in the county and in fact are more widely distributed than is generally realized. Sparse sulfide mineralization with quartz or calcite occurs in both the rocks of the Franciscan group and the quartz diorite of Inverness Ridge. No small effort has been expended in exploring these occurrences over the years from the Gold Rush almost to the present; except for some copper ore produced in 1918, a few caved tunnels and overgrown mine dumps are the only reminders of the activities. The copper, gold, and silver listed among the commodities produced in 1918 came from the Bolinas mine in Union Gulch east of Woodville.

Union Gulch Copper Deposit. Small amounts of chalcopyrite associated with pyrite occur in Franciscan sandstone on the west slope of

Bolinas Ridge, and some ore was produced as recently as 1918. Most of the work has been done in Union Gulch 0.7 mile northeast of Woodville on State Highway 1 on property now owned by J. G. Wilkins.

The deposit in Union Gulch was first worked in 1863 by the Union Copper Mining Company. Development work included a shaft and tunnel several hundred feet long. Although the exploration was continued for a number of years and some selected ore was shipped, no significant ore body was discovered (Watts, 1893, p. 253).

In 1896 the Bolinas Copper Mining Company did further work in Union Gulch, and some ore was shipped in 1900 (Calif. Min. Bur., 1896, p. 59). The mine, which was idle in 1902, included a shaft 180 feet deep sunk in the bottom of the gulch and 2500 feet of drifts on two levels. The shaft was served by a 30 horsepower hoist, and a crushing and concentrating plant was housed in a 50 by 100 foot building. A stockpile contained 200 tons of ore (Calif. Min. Bur., 1902, pp. 143, 144). The Chetco Mining Company reported the production of 22,500 pounds of copper in 1918, probably from the deposit in Union Gulch (Eric, 1948). Some silver and gold were also recovered.

In the summer of 1954 a little used foot path led from Woodville to the mine workings in Union Gulch. The foundations of the mill building remain, but two boilers are the only equipment left. Several tunnels, now caved, have been driven into both walls of the gulch at the site of the mill, and there is a second group of caved tunnels about 200 yards farther up the gulch. At the upper locality an open stope about 4 feet wide and 30 feet long has been excavated from one of the tunnels to the surface.

The rock in the vicinity of the mine workings consist predominantly of fractured sandstone. A minor amount of sheared black shale is present also, both in the outcrops near the site of the mill and in the dumps. The tunnels have been driven on shear zones that strike approximately north and dip steeply east. The mineralization consists of veinlets of quartz impregnated with oxidized sulfides. Although some specimens of massive chalcopyrite have been obtained, neither the existing exposures of the mineralized zones nor the waste dumps contain evidence of significant mineralization.

McKinnan Gulch Prospect. Probably in the 1930's some prospecting was done on a copper showing on Bolinas Ridge at the head of McKinnan Gulch. This is close to the prospect on the former Morse ranch, mentioned by Watts (1953, p. 252). The deposit is 100 yards west of the Bolinas Ridge road but is not visible from it. The outcrop has been opened with a test cut about 5 feet square and 5 feet deep and a cross cut tunnel driven eastward from a point on the slope below the outcrop. Although the tunnel has caved, the dump material shows that the mineralized zone was reached. A specimen from the outcrop was recently donated to the Division of Mines by John D. Swearingen of Mill Valley.

The country rock in the vicinity of the prospect is Franciscan sandstone. The immediate wall rock is black shale, and adjoining the shale on the west is a body of altered porphyritic lava. Massive green chert crops out close to the shale also. The ore minerals occur in a stock work of coarsely crystalline white calcite that cuts the shale and has bleached

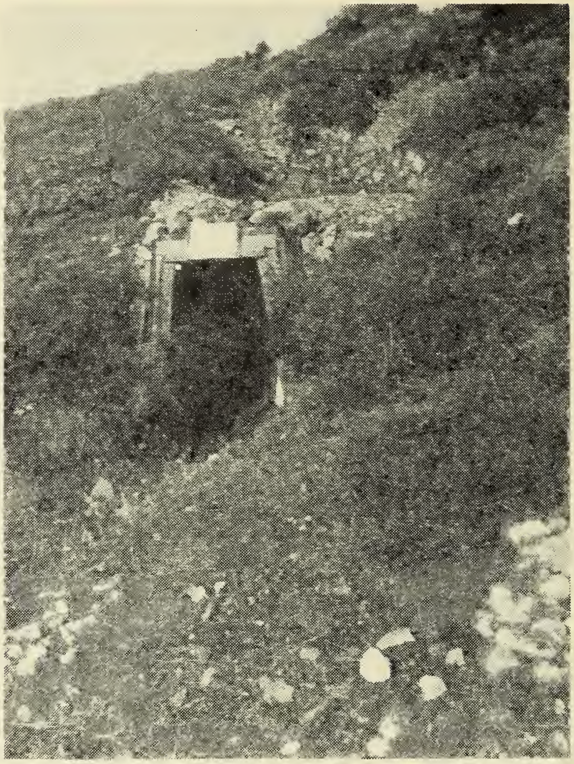

FIGURE 23. McKinnan Gulch copper prospect, Bolinas Ridge. Crosscut tunnel driven in the 1930s to intersect a deposit of chalcopyrite, pyrite, and galena associated with calcite. The country rock is sandstone and shale of the Franciscan group.

the shale close to it. Pyrite, chalcopyrite, and galena occur in the bleached shale along the calcite contacts and in the calcite also. In the dump material as well as in the outcrop scattered sulfide crystals up to an eighth of an inch in size were observed.

Other Prospects on Bolinas Ridge. Elsewhere along the western edge of the San Francisco-Marin block a number of additional occurrences of sulfide minerals have been prospected. Pyrite and chalcopyrite associated with quartz have been reported about a mile south of Union Gulch in Pike Gulch (Calif. Min. Bur. 1902, p. 143), and the occurrence was prospected by the Pike County Gulch Mining Company about 1863. At an early date some work was done on a silver prospect on a southwest spur of Mount Tamalpais (Watts 1893, p. 252), and Watts also mentions some prospecting about 5 miles north of Bolinas.

San Geronimo Prospect. At various times the silica-carbonate rocks of the Franciscan group have been prospected for gold and silver. In the late 1870's a substantial amount of development was done on a body of silica-carbonate rock at San Geronimo. The work included a shaft 200 feet deep, a cross cut, and several hundred feet of drifts both east and west on the mineralized structure. It is reported (Alley, Bowen & Co. 1880, p. 288) that the ore averaged $30 to $40 per ton in gold and contained in addition silver, iron, manganese, antimony, and traces of nickel. There is no record of production. The shaft, which has been filled as a safety precaution, was 200 yards north of the Sir Francis Drake Highway and 0.3 mile west of the San Geronimo-Nicasio road. It was sunk in an east-trending body of silica-carbonate rock that is bounded on the north by diabase. John D. Swearingen of Mill Valley states that the silica-carbonate rock contains disseminated chromite. The material on the surface of the dump consists of silica-carbonate rock and diabase with a minor amount of sandstone and shale.

In 1879 the San Rafael and Coast Range Mining Companies were interested in what was probably a body of silica-carbonate rock near San Anselmo. Assays rich in gold and silver were reported, but this venture seems not to have passed the promotion stage.

Point Reyes Peninsula. Gold in small amounts is associated with the granitic and metamorphic rocks of Inverness Ridge and has been taken from the stream gravels. E. A. Bender reports that there is an old prospect shaft, probably sunk for gold, on his property west of Willow Point. A beach placer on Tomales Point was worked in the 1860's (Calif. Min. Bur. 1888, p. 342; Alley, Bowen & Co. 1880, p. 311).

MINERAL CONSUMING INDUSTRIES

Although Marin is not a manufacturing county it does contain industries that consume nonmetallic, or industrial, minerals. Metal ores are commonly sold to smelters, and the marketing of them is comparatively simple. The marketing of the industrial minerals is usually more complex because many are used in their natural state modified only by simple treatments like grinding. In this period of high freight rates manufacturers desire to use local raw materials, but many are forced to rely on distant supplies. Traces of impurities, color, and particle shape or size are some of the factors that determine whether or not a product is useful. In many cases one product cannot be substituted for another unless substantial adjustments are made in the manufacturing process.

The manufacturing industry of Marin County is small but diversified. In 1947 there were 57 plants with 744 employees, and the value added in manufacturing was $3,333,000. The food products, lumber products, printing, chemical, luggage, stone and clay products, metal products, and transportation equipment industries are among those represented. Two plants in 1954 had 100 employees or more. Some Marin County plants that consume industrial minerals are described in the following pages.

Cement Gun Construction Company (1771).* The Cement Gun Construction Company of Marinship uses gunite for a host of purposes including lining swimming pools, ditches, mine workings, and repairing buildings. The lining of stacks for boiler plants is also performed. In guniting, portland cement mixed with sand as the aggregate is sprayed into place with compressed air. The dry ingredients are fed to the nozzle where they are mixed with the proper amount of water supplied through a separate pipe.

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* These industry classification numbers are those used by the Federal Government. See Standard industrial classication manual, vol. 1, part 2, manufacturing industries, 1945, U. S. Bureau of the Budget; and Standard industrial classification manual, vol. 2, nonmanufacturing industries, 1949, U. S. Bureau of the Budget.

The principal aggregate used is concrete sand obtained from a building materials supply dealer in San Rafael. Some finer plaster sand is added to obtain the desired particle size distribution. For lining stacks aluminite cement is used with a fine size of the lightweight aggregate Haydite. Concrete thus made is sufficiently light, strong, and refractory for the purpose.

American Distilling Company (2085). One of the principal distilleries of the American Distilling Company is on Bridgeway Boulevard at Nevada Street north of Sausalito. The only industrial mineral consumed at this plant is a low-iron grade of diatomite from southern California, used as a filter aid.

*Basic Chemicals Incorporated (2819).** Basic Chemicals Incorporated, Marinship, produces crystalline zinc ammonium chloride for use as a flux in brazing. Two products are made, $ZnCl_2 \cdot 2NH_4Cl$ containing 42.56 percent ammonium chloride and $ZnCl_2 \cdot 3NH_4Cl$ containing 54.06 percent ammonium chloride. The di-ammonium chloride forms flattish crystals, while the tri-ammonium chloride forms cubic crystals.

Raw materials are ammonium chloride, obtained at present from England, hydrochloric acid received in tank trucks, and zinc skimmings from galvanizing plants in the San Francisco area. Zinc chloride is prepared by dissolving the skimmings in acid. Insoluble matter settles to the bottom of the dissolving tank; and the liquor, after treatment with potassium permanganate ($KMnO_4$) to remove any iron present, is passed through a filter with diatomite as the filter aid. The most satisfactory brand that has been tried is Kenite ''700'' produced in Scarsdale, New York.

The clarified zinc chloride solution is mixed with the required amount of ammonium chloride and concentrated by boiling in a monel tank heated with steam coils. The hot concentrated solution is mixed with reconditioned mother liquor and run into domestic bath tubs in which crystals of zinc ammonium chloride form as the liquor cools. Each batch requires 43 tubs. After three days the mother liquor is drawn out, reconditioned by treatment with potassium permanganate followed by filtration, and mixed with freshly prepared zinc ammonium chloride solution.

The crystals that remain in the tubs are shoveled out and passed through small rotary driers that reduce the moisture to a few tenths of a percent. After screening, the crystals are packed in drums for shipment.

*Insulating Refractories Company (3255).*** Insulating Refractories Company, P. O. Box 322, San Rafael, has operated a plant adjoining the McNear Brick Company plant at McNear Point since 1946. George W. Maisac is Manager. Lightweight fire brick in special shapes are produced for domestic furnaces and similar purposes. The company's market area includes most of the United States.

Porosity in lightweight refractories is usually obtained by the use of a material such as crushed walnut shells, crushed olive pits, or ground cork that burns out during the firing. The management of this plant feels, however, that better control is obtained by using a lightweight, inert material that does not burn out.

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* Plant visit June 11, 1954.
** Plant visit May 24, 1954.

The principal raw materials are Green Stripe fire clay from Lincoln, Placer County, expanded vermiculite, and a little portland cement. Vermiculite, which comprises 75 percent of the mix by volume, is processed in Sacramento.

Raw materials are pugged with a small amount of water and pressed into shape with dies operated by a hydraulic press. The green pieces are burned in an oil fired four burner tunnel kiln without preliminary drying.

The tunnel kiln is a continuous kiln through which pass cars that bear the pieces to be fired. Burners are located in the central section, while preheating and cooling are accomplished in the end sections. At the Insulating Refractories Company plant the rate of charging may be varied to suit the production schedule. Usually the rate of feed is such that a given car remains within the kiln for about 10 hours, but this time may be as little as 4 hours. Pieces are fired to cone 06 at which temperature incipient vitrification of the clay takes place.

The use of portland cement makes it possible to shock heat the pieces and minimizes the shrinkage. Refractories produced at this plant are accurate to $\frac{1}{32}$ inch and can stand temperatures of up to 2000° F. The lightweight aggregate Haydite may be substituted for vermiculite, but the weight is increased and insulating value reduced. Perlite, however, cannot be used.

Heath Ceramics, Incorporated (3269). Heath Ceramics, Incorporated, 791 Bridgeway Boulevard, Sausalito, produces stoneware pottery from purchased clays. Two processes are used. In one the pieces are shaped by jiggering, that is they are formed on a revolving wheel with a template. Slip casting is the other process. A slip or thin slurry of clay and water with a dispersing agent is prepared and poured into molds made of a special grade of gypsum plaster called pottery plaster. As the water is absorbed by the porous mold, clay is deposited; and after the layer of clay is thick enough the excess slip is poured out. The molds are then opened and the green ware removed.

Green ware from both processes is fired after it has been dried and the glaze applied. The firing temperature is high enough to reduce the porosity of the product to a low figure.

Raw materials include two light burning refractory clays produced in the Sacramento area.

*Wallace Studios (3269).** Wallace Studios is a pottery shop at Forest Knolls that is owned by the three Wallace brothers. It has been idle since December 1953. The Wallace brothers produced stoneware in a small scale operation largely by hand methods. Special attention was paid to the glazes, and the partners succeeded after much experimentation in duplicating a number of old Chinese glazes. Some ware, particularly rectangular flower holders, was cast; but much of the output was hand thrown on the traditional potter's wheel. After the pieces had dried, glazes were applied, and they were fired to between 2100° and 2400° F.

Raw materials were obtained from ceramic supply houses in the San Francisco Bay area. Materials for the bodies included Newman Red clay, ball clay, flint (silica), talc, and fluorspar. A partial list of the glaze ingredients included fluorspar, red lead, colemanite, flint glass cullet, rutile, white lead, pyrophyllite, dolomite, nepheline syenite, black sand, and shale.

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* Visit August 30, 1954.

McNear Brick Company (3271).† The McNear Brick Company produces lightweight concrete building blocks at McNear Point. The aggregate is Haydite, an expanded shale product manufactured by the company at McNear Point as described in another section of this report.

A fine size of Haydite is batch mixed with portland cement, water, and a little sand and fed to either a Stearns Joltcrete machine or a Lith-I-Block machine which is entirely automatic. The wet concrete is measured into a charging box and discharged into the form by means of revolving screws within the box. When the charging box is empty it is withdrawn for refilling, while the concrete is pressed into the form. As soon as this has been accomplished the form is lowered into the clear so that the blocks can be thrust from the machine. The form then rises, and the machine is ready for the next cycle. Two blocks are made at a time. The blocks are hand loaded on carts and steam cured.

*Mill of Marin (3271).** Mill of Marin is a building and construction material supply house on U. S. Highway 101 at the Corte Madera wye, Corte Madera. Lightweight building blocks have been produced, but the block machine was being moved when the plant was visited. Pumice was the lightweight aggregate used. The usual supply came from the Basalt Rock Company's Mount George deposit, Napa; but red scoria from the Napa area as well as Haydite were tried. Freight rates to this locality on pumice from Inyo County and Modoc County are prohibitively high.

*Travertite Company Incorporated (3271)**. The Travertite Company Incorporated, P. O. Box 204, Mill Valley, manufactures terrazzo at Alto in a building formerly used as a power station by the Northwestern Pacific Railroad. Terrazzo is concrete prepared from portland cement and crushed colored stone. The concrete is cast into slabs on a table or less commonly in cylindrical forms. After the concrete has set it is polished with progressively finer carborundum wheels. Mineral pigments are added to some products, and some are finished with the bush hammer rather than polishing.

Several sizes of aggregate from $\frac{3}{4}$ inch to $\frac{1}{4}$ inch are used. Brightness of color is an important property. The aggregate for most of the terrazzo is white marble and gray-green verde antique produced by Sonora Marble Aggregates Company, Sonora, California. Some of the higher priced products contain red or black and gold marble aggregate from Italy that has been in stock for some years.

*Fiberaised Bar and Line Company (3272).*** Fiberaised Bar and Line Company, Marinship, produces triangular traffic guides and other shapes for use on streets and highways. The traffic guides are made by casting a mixture of gypsum plaster and wood fiber with resins and waxes for waterproofing, while other products, which contain sand as the aggregate, are extruded.

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† Plant visit May 24, 1954.
* Visit July 29, 1954.
** Plant visit July 30, 1954.

Most of the plaster used is a special high strength, low consistency casting plaster; but some common reground kettle casting plaster is also used. A lightweight substitute for sand in the extruded product is desired.

*Perolite Products (3295)**. Perolite Products produces expanded perlite for plaster aggregate, concrete aggregate, and acoustical plaster at Marinship. The capacity of the plant is 2500 pounds per hour, but the average daily output is perhaps two tons.

The plant feed is purchased raw perlite ground to the specified size and shipped in box cars to keep it dry. When the plant was visited 90 percent of the perlite was produced by the California Perlite Company near Barstow, California, but some white perlite for the production of acoustical plaster was obtained from Florence, Colorado. In particle size the Barstow perlite ranges from 16 mesh to 100 mesh with 75 percent coarser than 50 mesh. The Colorado perlite falls within the same size range, but 85 percent of it is coarser than 50 mesh.

Raw perlite is stored under cover. From storage it is shoveled through a grizzly to a screw conveyor that brings it to a vibrating feed hopper. The raw perlite is thus introduced into a rotary, gas fired furnace inclined at a slight angle. The perlite is preheated as lifters propel it through the space between the outer shell and an inner liner. At the firing end of the furnace the perlite drops off the liner into the flame and is swept through the inner cylinder. A cyclone type of dust collector mounted on the roof of the building separates the expanded perlite from the furnace gases. The perlite drops into a bin in the building below from which paper bags are filled, and the gases with but a little dust in the minus 200 mesh range escape into the atmosphere.

Expanded perlite is shipped in paper bags of either three or four cubic feet capacity. Plaster aggregate weighs 7½ pounds per cubic foot, while concrete aggregate, which is used in non-load-bearing structures, weighs 8½ pounds per cubic foot. Both grades are made from the same crude perlite. The properties of the expanded perlite are controlled by varying the furnace temperature and the time that the perlite remains within the furnace.

A second furnace has been installed for experimental purposes. It consists of a vertical shaft about 12 inches in diameter fired with gas at the bottom. Raw perlite is introduced near the bottom; and the light, expanded perlite leaves from the top with the exhaust gases.

*San Rafael Iron Foundry (3271).*** The San Rafael Iron Foundry, 78 Woodland Avenue, San Rafael, is a jobbing foundry that produces gray iron castings of a maximum of 500 pounds in weight. Scrap iron is melted in direct contact with metallurgical coke in a cupola or shaft furnace and cast in green sand molds. The special sands used for foundry molds comprise an important group of industrial minerals.

Foundry sands are used for two purposes, molds and cores. Molding sand contains a clay binder, present naturally in naturally bonded sand or added at the foundry in the case of synthetic sand. The larger foundries today are tending to use synthetic sand because the properties of the sand can be closely controlled by the foundrymen. The use of synthetic sand necessitates a substantial investment in sand conditioning equipment, and the smaller foundries continue to use naturally bonded molding sands.

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* Plant visit June 11, 1954.
** Visited July 29, 1954.

Molding sand must have bonding strength so that when it is properly moistened and rammed the mold is strong enough to withstand handling and the hydrostatic pressure and erosion of the liquid metal. It must, in addition, be porous to permit the escape of gases and refractory so that the grains do not fuse and close the pores. The sand grains must also be tough to resist crumbling at the contact of the hot metal. Molding sand is re-used, and comparatively small amounts of new sand are added from time to time to make up losses.

If the casting has a hollow space, the mold is provided with a sand core. Sands for cores are clay free, and binders such as core oil, corn flour, or perhaps a little fire clay or bentonite are added. After being formed, the cores are baked. Like the molds, the cores must be permeable and refractory. They must, in addition, retain their strength and shape while the iron is liquid but collapse as the solidifying metal contracts. Cores are always made from new sand, and used core sand is discarded.

For molding sand the San Rafael Iron Foundry uses a fine, naturally bonded sand from Santa Ana, California. Del Monte sand is used for cores.

Monument Shops (5999). San Rafael contains two comparatively small shops where granite and marble monuments are finished. One is the Marin Monument Company at 1614—4th Avenue and the other is that of L. T. Corti at 2468—5th Avenue.

The smaller shops commonly purchase monuments that are finished except for the lettering. After the design has been drafted it is transferred to a stencil. The stencil is cemented on the stone, and the design is etched into it by sandblasting.

For blasting sand both San Rafael shops use silica sand from Ottawa, Illinois, of approximately 30 mesh size. The abrasive is recovered, screened, and re-used. Monterey County beach sands, which are widely used for outdoor sandblasting, are too friable for monument cutting. Synthetic abrasives are available that cut faster and wear longer than silica sand, but usually the use of these more expensive materials is economical only in the larger shops.

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LIST OF MINES AND MINERAL DEPOSITS

Chromite

Map number	Claim, mine, or group	Owner, name, address	Location	Remarks
	Maillard Ranch	Marin Municipal Water Co.	½ mi. S. Woodacre	Chromite float found in serpentine area. Chromite in place not found. (Calif. Min. Bur. 94:37; Dickerson 22:593) Div. Mines museum specimen No. 14053.

Clay

Map number	Claim, mine, or group	Owner, name, address	Location	Remarks
	Bothin (Bothin tract, Bothing Home)	Bothin Convalescent Home	Bothin	Small scale production of pottery from local clay by inmates of Bothin Home. Active 1914. (Bradley 16:244)
	Fortin Brick Co.: See L. P. McNear Brick Co.			
(4)	Greenbrae tile plant		Greenbrae	Unidentified; possibly synonymous with Louis Sbarbori, which see. (Symons 28:264)
(3)	Hidecker Brick Co.		Gallinas Station	Crushed waste brick at defunct Patent Brick Co. yard, which see. Used in manufacture of roofing tile. Active 1923-1925 incl. (Laizure 26:319)
	Lagunitas Development Co. (Maillard Ranch)	Lagunitas Development Co.	Spring Creek near Lagunitas	Common clay used locally for brick about 1892. (Watts 93:253; Bradley 16:247)
1	McNEAR BRICK CO. McNear Point, San Rafael	The McNear Company	McNear Point	Lightweight aggregate Haydite produced from Franciscan clay shale. The brickyard operated prior to 1932 now operated by L. P. McNear Brick Co., which see.
2	L. P. McNEAR BRICK CO. (McNear Brick Co., Fortin Brick Co.), McNear Point, San Rafael	The McNear Company	McNear Point	Common brick produced from Franciscan clay shale by stiff mud process and burned in two Hoffman kilns. Operated by McNear Brick Co. prior to 1932 and reopened by present company 1947. (Calif. Min. Bur. 94:382; Calif. Min. Bur. 06:249; Bradley 16:244-247; Laizure 26:317-319; Dietrich 28:124, 125)

Clay—Continued

Map number	Claim, mine, or group	Owner, name, address	Location	Remarks
	Maillard Ranch: See Lagunitas	Development Co.		
3	Patent Brick Co.	Remillard-Dandini Co.	Gallinas Station	Common and pressed brick. Stiff mud process substituted for soft mud process 1904. Two Hoffman kilns and oil-fired down-draft kiln. Production approx. 1870-1909. (Calif. Min. Bur. 06:250, Bradley 16:247, 248)
4	Remillard Brick Co.	Remillard-Dandini Co.	Greenbrae	Common brick produced by the soft mud process. One Hoffman kiln. Production 1891-1913 incl. (Watts 93:254; (Calif. Min. Bur. 94:382; (Calif. Min. Bur. 06:250)
(4)	Louis Sbarbori		Greenbrae	Leased Remillard Brick Co. property about 1926; planned to produce floor tile. No recorded production. (Laizure 26:319)

NOTE: Numbers in parentheses are map numbers of existing or better known operations at the same locality.
Names in capitals indicate operating mines or quarries.

Coal

Map number	Claim, mine, or group	Owner, name, address	Location	Remarks
(30)	Escalle quarry		Larkspur	Occurrence of impure lignite in Franciscan shale associated with "blue" sandstone. (Bradley 16:254)
	McGovern Ranch (Pine Gulch?)	Francis Clark	2 mi. N. Bolinas	Prospecting reported (Watts 93:251) Samples exhibited in San Francisco (Parker 93:214)
5	Murray Ranch	G. F. Rogers et al	2.3 mi. NE. Nicasio	Occurrence reported (Watts 93:251) Tunnel and shaft in sandstone, date not ascertained.
	Overton Ranch		Tomales Bay. Location not ascertained.	Div. Mines museum specimen No. 11523
	Pine Gulch: possibly synonymous	with McGovern Ranch, which see		

Copper

Map number	Claim, mine, or group	Owner, name, address	Location	Remarks
(7)	Bolinas mine: see Union Gulch			
(7)	Chetco: see Union Gulch			
6	McKinnan Gulch		Bolinas Ridge at the head of McKinnan Gulch	Pyrite, chalcopyrite, and galena in calcite vein cutting shale. Prospected with open cut and tunnel, probably in the 1930's. Div. Mines museum specimen No. 21566.
(7)	Pearson & Brothers mine: see Union Gulch			
	Pike Gulch	Mary Galloway	Woodville, exact location not ascertained.	Copper showing consisting of a 4-foot vein of low grade copper ore with pyrite. Explored 1873-1876 with 700-foot tunnel by Pike County Gulch Mining Co. (Alley, Bowen & Co. 80:272, 273; Calif. Min. Bur. 02:143; Calif. Min. Bur. 06:168).
7	Union Gulch (Bolinas mine, Chetco, Pearsor & Brothers mine)	J. G. Wilkins	0.7 mi. NE. Woodville	Two groups of workings driven on fracture zones in sandstone. Mineralization is veinlets of quartz with chalcopyrite and pyrite (Div. Mines museum specimens 12,859 and 15,376). Union Gulch Mining Co. made small shipments in 1863. Bolinas Copper Mining Co. sank shaft, built mill, and shipped ore in 1900. Chetco Mining Co. produced ore containing 22,500 pounds copper plus gold and silver in 1918. (Alley, Bowen & Co. 80: 272, 273; Watts 93:253; Calif. Min. Bur. 96:59; Watts 00:14; Calif. Min. Bur. 02:143; 144; Calif. Min. Bur. 08:168, 169; Eric 48:264).

Gems

Map number	Claim, mine, or group	Owner, name, address	Location	Remarks
8	Lime Point	U.S. Government	North tower, Golden Gate Bridge	Jasper taken from tower excavation and the adjacent shore, 1935. (Div. Mines museum specimen No. 20627).
9	Massa Hill	M. Vonsen	Sec. 19, T. 5N, R. 7W, MD	Veins and lenses of nephrite in sheared serpentine (Chesterman 51).

Gold and Silver

Map number	Claim, mine, or group	Owner, name, address	Location	Remarks
	Fort Baker manganese deposit	U.S. Government	Fort Baker	Manganese ore with a small amount of gold (Lawson 14:23).
	Inverness Ridge			Small quantities of gold occur in streams on the northeast slope of Inverness Ridge. A tunnel and shaft on the E. A. Bender property are probably gold prospects.
	Morse ranch		Bolinas Ridge, exact location not ascertained	Limited prospecting prior to 1890 (Watts 93:252).
10	Mt. Tamalpais		SW. spur of Mt. Tamalpais	Limited prospecting (Watts 93:252) (Div. Mines museum specimen No. 14364).
	Randall		5 mi. N. Bolinas	Small quartz vein cutting sandstone and shale. Assayed \$1.25/ton gold and \$7.85 silver. Test pit sunk 1889 (Watts 93:252).
11	San Geronimo		Sir Francis Drake Highway at San Geronimo	200-foot shaft and several hundred feet of drift excavated in silica carbonate 1878. Assays of \$30 to \$40 per ton reported (Alley, Bowen & Co. 80:288). No record of production.
	Tomales Point		Ocean side of Tomales Point, exact location not ascertained	Beach placer worked in the 1860's. (Alley, Bowen, & Co. 80:311; Calif. Min. Bur. 88:342).
(7)	Union Gulch: see under copper			

Limestone

Map number	Claim, mine, or group	Owner, name, address	Location	Remarks
(43)	Bender	E. A. Bender	¾ mi. W. Willow Point, Tomales Bay	Coarsely crystalline white limestone. Undeveloped. See also Bender tungsten deposit.
12	Lockhart (Lockhart tract)	E. N. Lockhart	Laguna Ranch Rd., Inverness Ridge	Coarsely crystalline white limestone opened by small pits and cuts. Stone may have been burned in kilns at the foot of Laguna Ranch Rd. (Eckel 33:353; Logan 43:251, 252; Weaver 49b:16)
(12)	Lockhart tract: see Lockhart			
13	Olema ("Russian kilns")	Sam Smoot	4½ mi. S. Olema	Small quarry in lens of Franciscan limestone. Three old stone lime kilns formerly considered to be of Russian or Spanish origin are now believed to have been built by Americans in the early 1850's. (Eckel 33:356, 357; Logan 47:251; Treganza 51: 65-72)
(13)	"Russian Kilns":	see Olema		
	Trout farm	R. L. Griffith	Trout farm, Tomales Bay	Old quarry in coarsely crystalline, white limestone (Eckell 33:353; Logan 47:252)
	Tomales Bay: See Lockhart and Trout Farm			

Lead

Map number	Claim, mine, or group	Owner, name, address	Location	Remarks
(6)	McKinnan Gulch: see under copper			

Manganese

Map number	Claim, mine, or group	Owner, name, address	Location	Remarks
	Fort Baker	U. S. Government	Fort Baker	18 inches of psilomelane in chert near contact with ellipsoidal basalt. Undeveloped. (Lawson 14:23; Trask 50: 105).
14	Knutte	Louis J. Glicksberg	1 mi. S. Novato	Manganese oxides associated with chert lens in sandstone. Production 1942-1945 incl. from two open cuts by L. R. Knutte, lessee. (Div. Mines museum specimen No. 21191).
15	Mailliard Ranch	Marin Municipal Water Co.	½ mi. S. Woodacre	Manganese oxide streaks and patches in blocks of jasper caught up in serpentine. Undeveloped. (Watts 93:252; Bradley 18:48; Dickerson 22: 593; Trask 50:106) Div. Mines museum specimen No. 14052.
16	Mazza (Mazza Ranch)	Francis A. Mazza	2½ mi. SE. Union School	Body of mixed manganese carbonate and silica 15 feet thick. Developed by M. Vonsen, World War I. No production. (Trask 50:106)
(16)	Mazza Ranch: see Mazza			
	Petaluma-Pt. Reyes	Respini and Morelli	N½ sec. 30, T.4N., R. 7W, MD. B&M	Black manganese oxides 3 ft. thick, traced 40 feet. Undeveloped. (Trask 50:106).
	Sausalito Point	Marin Land and Cattle Co.	1 mi. W. Sausalito Point	Pockets of manganese oxide up to 3 ft. dia. in jasper. Small production 1882. (Penrose 91:489, 490; Harder 10: 164, 272; Bradley 18:38; Trask 50:106). Div. Mines museum specimen No. 8672.

Mercury

Map number	Claim, mine, or group	Owner, name, address	Location	Remarks
17	Gambonini	M. Gambonini	North bank of Salmon Creek 6 mi. E. Marshall	Rich but superficial pods of cinnabar. Discovered 1945 by Ferdinand Stover. Explored 1945-1948 by Cordero Mining Company. No production.
	Point Reyes Peninsula		Exact location not ascertained	Discovery of cinnabar on Pt. Reyes reported 1875 (Mining and Scientific Press 75).

Mineral Water

Map number	Claim, mine, or group	Owner, name, address	Location	Remarks
	Ancha Vista Spring		Red Hill, San Anselmo	21 grains/gallon, mainly lithia and magnesia. Used in nearby resort, some shipped in carboys about 1915. (Bradley 16:249; Laizure 26:321).
	El Toro Spring		2½ mi. N. Novato	Water reported bottled at one time. Analysis (Watts 93:251; Waring 15:255, 256).
	Rocky Point Hot Sulphur Springs	William Kent estate	On the shore 6 mi. NW. Point Bonita	Mildly sulfurated warm water, perhaps from oxidizing pyrite. Undeveloped. (Watts 93:251; Waring 15:80, 81).
18	Tamalpais Mineral Well		First and Hayes Sts., San Rafael	26 ft. deep, 6 ft. diameter. Sunk 1903. Mildly saline. Bottled and sold by Borello Brothers. Production reported 1908-1930 incl. Analysis. (Waring 15:307, 308; Bradley 16:250; Laizure 26:321).
19	Woodacre Iron Spring	Lagunitas Development Co.	Woodacre	Not used. Laizure 26:322.

Map number	Claim, mine, or group	Owner, name, address	Location	Remarks
20a	Duxbury Point Wells (Garzolia Ranch)*		Sec. 24(?), T.1N, R8W, M.D., B&M (proj.)	Drilled about 1904, T.D. 1,800 ft. Monterey. Small showings at 700 and 1,200 ft. (Vander Leck 21:36; Oakeshott 52:26).
20b	Duxbury Point Wells (Garzolia Ranch)*		Sec. 24? or 25?, T.1N, R.8W, MD, B&M (proj.)	Drilled about 1904, T.D. 1,800 ± ft. Monterey. No oil showing. (Vander Leck 21:36; Oakeshott 52:26).
20c	Duxbury Point Wells (Garzolia Ranch)*		Sec. 25(?), T.1N, R.8W, MD, B&M (proj.)	Drilled about 1904, T.D. 2,800 ± ft. Monterey. Showings at 200 and 2,400 feet. (Vander Leck 21:36; Oakeshott 52:26).
	Garzolia Ranch: See Duxbury Point Wells			
21	L. M. Lockhart, R.C.A. 3-1		Sec. 26, T.1N, R. 8W, MD, B&M (proj.)	Abandoned May, 1949. T.D. 8,409 ft. Base Santa Margarita shale 2,840, upper Mohnian Monterey shale 2,840-4,880, lower Mohnian shale 1,880-8,310, Luisian 4,880-8,409 (Oakeshott 52:62).
	L. M. Lockhart, Tevis 1: see Standard Oil Co. Tevis 1			
22	C. F. McCarthy et. al., No. 1		Sec. 14, T.3N, R.6W, MD, B&M (proj.)	Abandoned 1937. T.D. 812 feet (Oakeshott 52:26).
23	P. M. Oil Co. No. 1		Sec. 36, T.3N, R.9W, MD, B&M (proj.)	Abandoned June 1954. T.D. 1,670 ft. Franciscan. Trace of oil. (Munger 1 July, 1954).
24	Standard Oil Co., Mendoza 1, 2, 3		Sec. 22, T.2N, R.10W, MD, B&M (proj.)	Abandoned May 1951. T.D. 951 ft. (Munger 51).
25	Standard Oil Co., Robson 1		Sec. 33, T.2N, R.8W, MD, B&M (proj.)	Abandoned Oct. 1952. T.D. 7,286 ft. No showings. (Munger 52.)
26	Standard Oil Co., Tevis 1		Sec. 7, T.1N, R.8W, MD, B&M (proj.)	Abandoned May 1951. T.D. 6,587. Sand and shale. Drilled to 5,123 ft. by L. M. Lockhart and abandoned Jan. 1948. Standard Oil Co. took over the well April 1951 and deepened it to 6,587 feet. Showings of gas below 4,800 feet. (Munger 51).

---

* Vander Leck (Vander Leck 21) described two wells 1,800 feet deep near the Garzolia Ranch House and a third well close to the sea cliff. The map of Douglas (Douglas 43) shows two wells near the shore and one half a mile inland.

Potash

Map number	Claim, mine, or group	Owner, name, address	Location	Remarks
				Production of potash reported 1922 by Mason By Products Co., Sausalito. This material was potash char, equivalent K_2O content 36 percent, produced from distillery waste.

Salt

Map number	Claim, mine, or group	Owner, name, address	Location	Remarks
	Golden Gate Salt Corp.		Not ascertained	Production reported 1906 by James Baumberger. (Bradley 16:250; Laizure 26:322)

Stone Industries

Map number	Claim, mine, or group	Owner, name, address	Location	Remarks
	Angel Island (Fort McDowell): not in Marin County			
27	Black Mountain	J. S. Burdell	2 mi. E. Point Reyes Station	Crushed stone produced from Franciscan chert by Marin Gravel Co. closed 1953. See also Burdell Mountain quarry and Lagunitas gravel deposit.
28	BLACK POINT	Henry Sartori; leased to Black Point Aggregates Inc., 115 Woodland Ave., San Rafael	½ mi. SW. Black Point Station	Aggregates for all purposes produced from cemented gravel by Black Point Aggregates Inc. First capacity production May 1954.

Stone Industries—Continued

Map number	Claim, mine, or group	Owner, name, address	Location	Remarks
(38)	Bull: See McNear Point			
29	BURDELL MOUNTAIN	Julia C. Bodkin; leased to Marin Gravel Co., Novato	2½ mi. N. Novato	Sonoma volcanics. Marin Gravel Co. constructing crushed stone plant 1954. Rock to come from former Taylor paving block quarry, which see. See also Black Mountain quarry and Lagunitas gravel deposit.
(38)	Daniel Contracting Co.: See McNear Point quarry			
	De Long		5 mi. N. Novato. Exact location not ascertained	Paving blocks, P. Gallagher, lessee (Watts 93:252).
30	Escalle	A. A. Tiscornia	Larkspur	Crushed stone produced from Franciscan blue sandstone. See aslo Escalle quarry under coal. Active about 1913. (Bradley 16:254).
31	FORBES	Marvelous Marin Realty Company	Quarry Road, San Rafael	Crushed stone including concrete aggregate produced from chert, approx. 1890-1910—(Calif. Min. Bur. 94:389; Calif. Min. Bur. 96:625; Calif. Min. Bur. 06:318; Bradley 16:254). Pit run material obtained by Jensen and Pitts, lessee. Active.
32	Fort Baker	U. S. Government	Fort Baker	Crushed stone. Used on Panama-Pacific Exposition grounds, San Francisco. Active about 1913. (Bradley 16:254; Laizure 26:323).
	Fort Barry: See Point Bonita			
	Fort McDowell (Angel Island): Not in Marin County			
	Gallagher		3 mi. N. Novato. Exact location not ascertained	Paving blocks, J. Gallagher, owner. Last production 1895. See also De Long quarry. (Calif. Min. Bur. 94:396; Calif. Min. Bur. 96:633).
(37)	Gray Brothers: See Marin			

Stone Industries—Continued

Map number	Claim, mine, or group	Owner, name, address	Location	Remarks
33	GREENBRAE	Hutchinson Company, 7360 Schmidt Lane, El Cerrito	Greenbrae	Jetty stone and crushed stone produced from blue sandstone. Opened 1925 (Laizure 26:325). Active.
	Hidecker Brick Co.		Not ascertained	Produced crushed "green rock" for use in manufacture of roofing tile. 1928.
34	Hoffman	Rose, Freitas, Rose, et al.	U. S. Highway 101 1 mi. N. Forbes overhead	Chert used for crushed stone. Active approx. 1905-1915. (Calif. Min. Bur. 06:319; Bradley 16:255).
35	Hotaling	W. S. Nock	S. end Clark Street, San Rafael	Blue sandstone cut by dike of light colored volcanic rock. Furnished crushed stone and dimension stone including that used for First Presbyterian Church, San Rafael. "Granite" shown in Marin County production table was from this quarry and could have been the volcanic rock. Active 1890—approx. 1915. (Goodyear 90:299; Calif. Min. Bur. 94:389; Calif. Min. Bur. 96:625; Calif. Min. Bur. 06:319; Bradley 16:255).
(38)	Jordan: See McNear Point			
36	LAGUNITAS CREEK GRAVEL DEPOSIT	J. S. Burdell	2 mi. E. Point Reyes Station	Joslin Brothers, Lessee. Aggregates for all purposes produced from Creek gravel, first production 1954. Operated by Marin Gravel Co. 1939-1953. See also Black Mountain quarry and Burdell Mountain quarry.
37	Marin	The McNear Company	South side San Pedro Point	Operated by Gray Brothers and Western Development Syndicate approx. 1900-1910. Leased 1914 by San Francisco Quarries Co. which see also under McNear Point quarry. Furnished jetty stone for use on San Francisco waterfront (Calif. Min. Bur. 06:319; Bradley 16:258).
	Marin Rock Company		W. edge San Anselmo. Exact location not ascertained	Rubble and crushed stone produced from blue sandstone production 1909—approx. 1920. (Bradley 16:255, 256).

Stone Industries—Continued

Map number	Claim, mine, or group	Owner, name, address	Location	Remarks
(38)	McNear: See McNear Point			
38	McNEAR POINT (Bull, Daniel Contracting Co., Jordan, McNear, S. F. Bay Improvement Co., S. F. Quarries Co., Wetmore Brothers.)	The McNear Company	San Pedro Point	Jetty stone and crushed stone produced from blue sandstone. Leased 1945 by Basalt Rock Co., 8th and River Streets, Napa. In operation. Two quarries. (1) NE quarry (Bull) opened 1904 by Bull and Gossard, later operated by Wetmore Brothers and acquired by Daniel Contracting Co. approx. 1913. (2) SW quarry (Jordan) opened 1876 by Dennis Jordan, later operated by S. F. Bay Improvement Co., acquired by S. F. Quarries Co. approx. 1910, and operated by Blake Brothers 1917-1920 incl. Acquired subsequently by Daniel Contracting Co. and operated with the NE quarry through 1940. (Calif. Min. Bur. 06:318, 319; Bradley 16:250-253, 258-260; Laizure 26:323).
39	Mt. Tamalpais Cemetery	James E. Gilchrist		Small quarry in blue sandstone. Produced dimension stone and crushed stone for use in the cemetery grounds which formerly included the quarry. Active approx. 1890-1920. (Watts 93:251, 252; Calif. Min. Bur. 94:389; Calif. Min Bur. 06:319; Bradley 16:256).
40	Nigger Hill	Rose, Freitas, Rose, et al.	Summit Burdell Mountain	Paving blocks produced from Sonoma volcanics. Closed before 1894.
	Point Bonita (Fort Barry)	U. S. Government	East side Point Bonita	Blue Franciscan sandstone. Furnished aggregate for concrete fortifications at Fort Barry. Active 1900-1917. Also a second quarry at Fort Barry active approx. 1917-1920 (Bradley 16:256; Laizure 26:326).
(38)	San Francisco Bay Improvement Co.: See McNear Point			
(38)	San Francisco Quarries Co.: See McNear Point			
	San Rafael Development Co.		Pine Hill, San Rafael	Chert. Active prior to 1914. (Bradley 16:260).
	Short Ranch		1 mi. N. San Anselmo. Exact location not ascertained	Two small quarries in blue sandstone. Dimension stone. Active approx. 1910-1920 (Bradley 16:260).

Stone Industries—Continued

Map number	Claim, mine, or group	Owner, name, address	Location	Remarks
(29)	Taylor	Thomas Hale	2½ mi. N. Novato	Paving blocks and dimension stone produced from Sonoma volcanics. Last production 1894. Reopened 1954 by Marin Gravel Co. which see under Burdell Mountain quarry. (Watts 93:252; Calif. Min. Bur. 94:396).
41	Tiburon Ridge	Thomas Deffeback	1 mi. W. California Point	Glaucophane Schist used as patio stone. A few hundred tons quarried by Samuel Newsom, Mill Valley, 1952 and probably others.
(37)	Western Development Syndicate:	See Marin		
(38)	Wetmore Brothers: See McNear	Point		

Tungsten

Map number	Claim, mine, or group	Owner, name, address	Location	Remarks
42	BENDER	E. A. Bender	Inverness Ridge ¾ mi. W. Willow Point	Detrital deposit overlying scheelite replacement of limestone at contact with quartz diorite. Discovered 1951. mill under construction 1954. The first confirmed discovery of scheelite in the Coast Ranges.
43	Noren	C. R. Noren	Inverness Ridge 1 mi. SW. Point Reyes Station	Scheelite replacement of limestone at contact with granite. Limited development 1952 by Knob Hill Mines Inc., Lessee.

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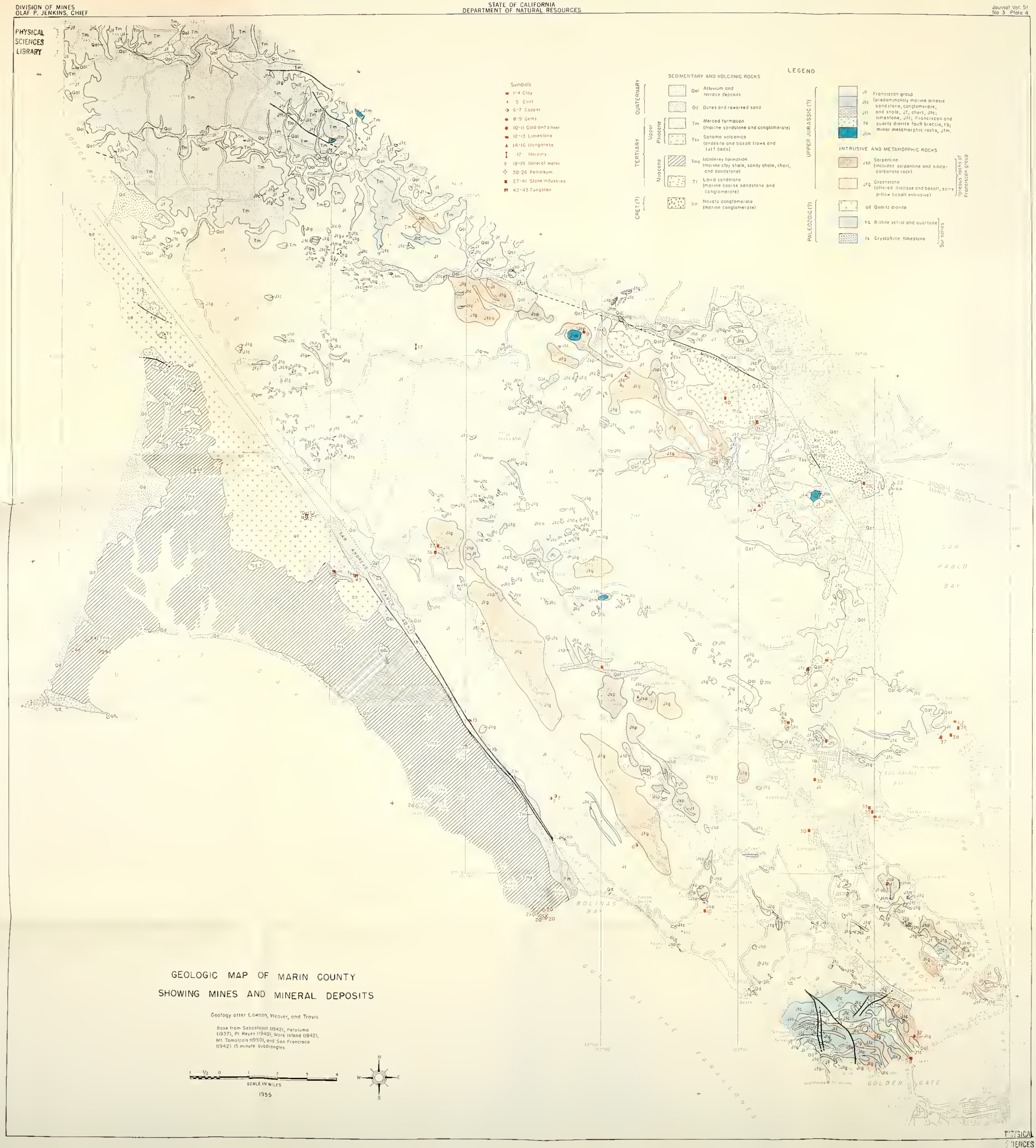
LEGEND
SEDIMENTARY AND VOLCANIC ROCKS
QUATERNARY
Qal Alluvium and terrace deposits
Qd Dunes and reworked sand
TERTIARY
Upper Pliocene
Tm Merced formation (marine sandstone and conglomerate)
Tsv Sonoma volcanics (andesite and basalt flows and tuff beds)
Miocene
Tms Monterey formation (marine clay shale, sandy shale, chert, and sandstone)
Tl Laird sandstone (marine coarse sandstone and conglomerate)
CRET.(?)
Kn Novato conglomerate (marine conglomerate)
UPPER JURASSIC (?)
Jf
Jfc
Jfl
fb
Jfm
Franciscan group (predominantly marine arkosic sandstone, conglomerate, and shale, Jf, chert, Jfc; limestone, Jfl; Franciscan and quartz diorite fault breccia, fb; minor metamorphic rocks, Jfm.
INTRUSIVE AND METAMORPHIC ROCKS
Jsp Serpentine (includes serpentine and silica-carbonate rock)
Jfg Greenstone (altered diabase and basalt, some pillow basalt extrusive)
Igneous rocks of Franciscan group
PALEOZOIC (?)
qd Quartz diorite
sq Biotite schist and quartzite
ls Crystalline limestone
Sur series
Symbols
1-4 Clay
5 Coal
6-7 Copper
8-9 Gems
10-11 Gold and silver
12-13 Limestone
14-16 Manganese
17 Mercury
18-19 Mineral water
20-26 Petroleum
27-41 Stone industries
42-43 Tungsten
BODEGA BAY
SAN ANDREAS FAULT
BURDELL MOUNTAIN FAULT
SONOMA COUNTY
MARIN COUNTY
SAN PABLO BAY
SAN RAFAEL BAY
BOLINAS BAY
GULF OF THE FARALLONES
RICHARDSON BAY
GOLDEN GATE
SAN FRANCISCO BAY
1 1/2 0 1 2 3 4
SCALE IN MILES
N
S
E
W

GEOLOGIC MAP OF MARIN COUNTY
SHOWING MINES AND MINERAL DEPOSITS

Geology after Lawson, Weaver, and Travis

Base from Sebastopol (1942), Petaluma (1937), Pt Reyes (1940), Mare Island (1942), Mt. Tamalpais (1950), and San Francisco (1942) 15 minute quadrangles.

1955

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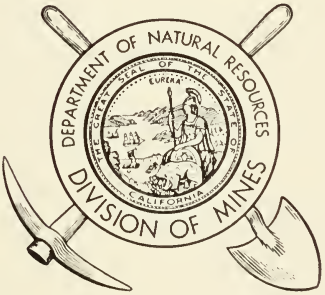

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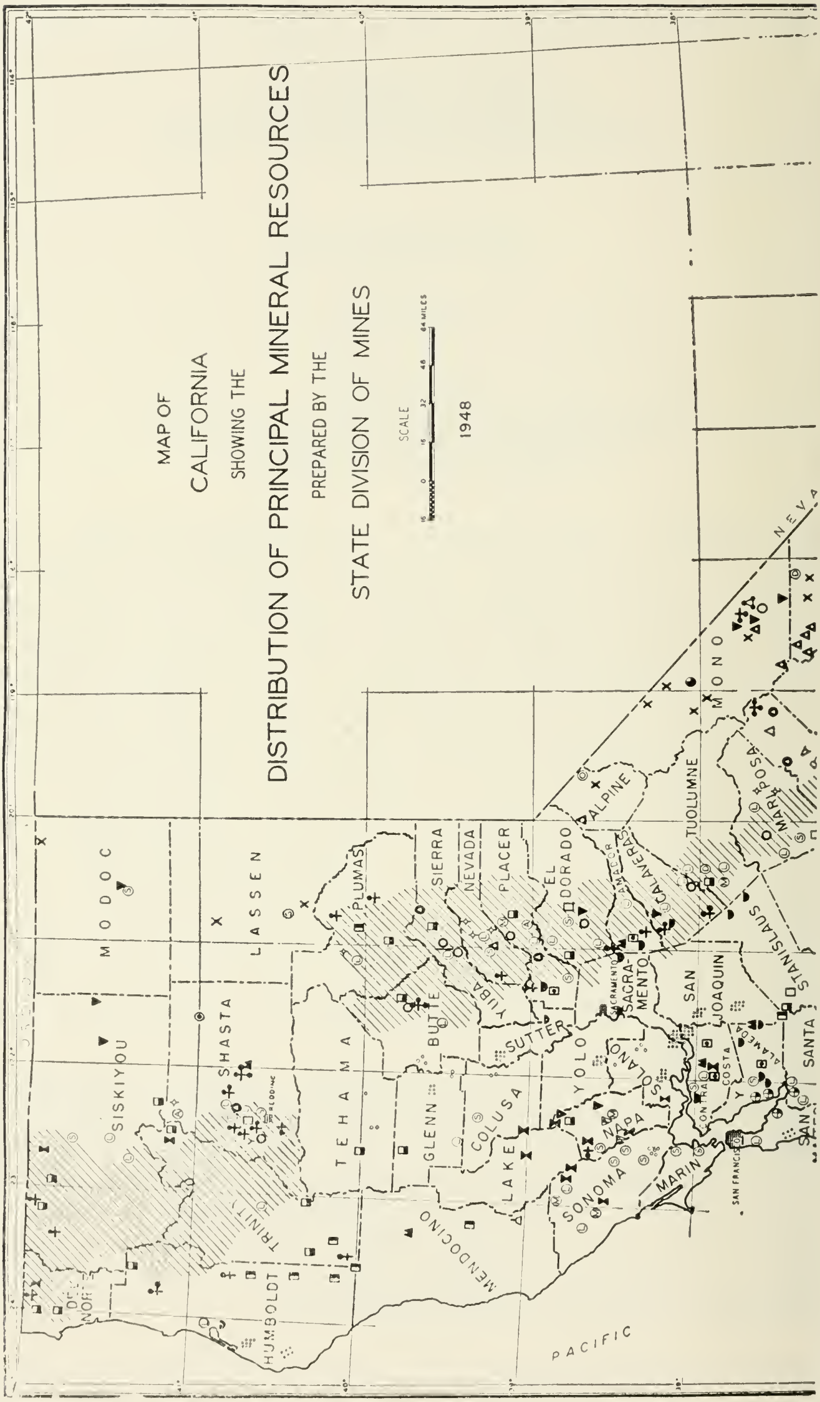
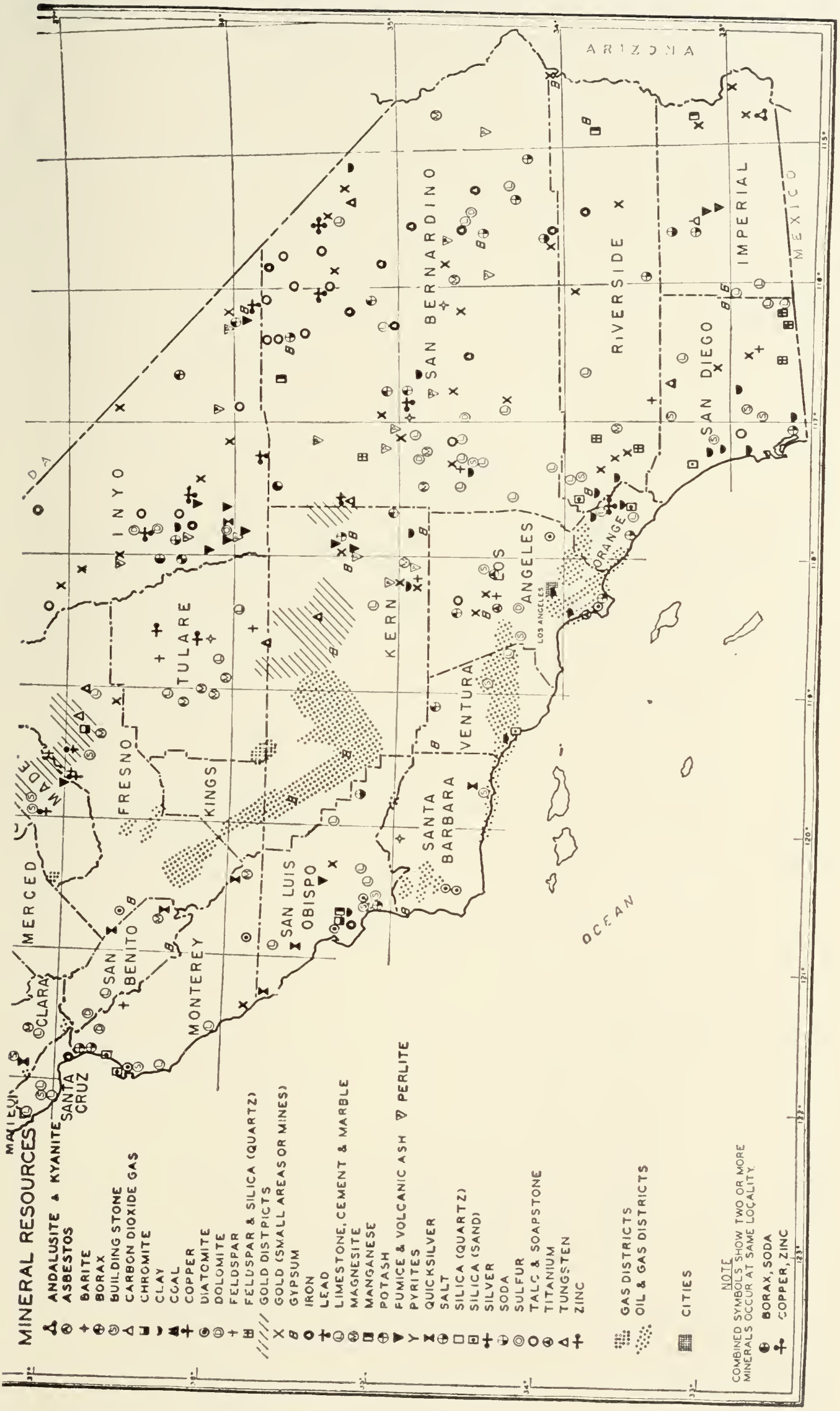

MAP OF
CALIFORNIA
SHOWING THE
DISTRIBUTION OF PRINCIPAL MINERAL RESOURCES
PREPARED BY THE
STATE DIVISION OF MINES
SCALE
1948
MODOC
SISKIYOU
SHASTA
LASSEN
TRINITY
HUMBOLDT
TEHAMA
PLUMAS
SIERRA
NEVADA
PLACER
BUTTE
GLENN
YUBA
SUTTER
EL DORADO
ALPINE
AMADOR
CALAVERAS
TUOLUMNE
MONO
MARIPOSA
MENDOCINO
LAKE
COLUSA
YOLO
SACRAMENTO
SAN JOAQUIN
STANISLAUS
SOLANO
NAPA
SONOMA
MARIN
CONTRA COSTA
ALAMEDA
SAN FRANCISCO
SANTA
SAN
PACIFIC
NEVADA


MINERAL RESOURCES
ANDALUSITE & KYANITE
ASBESTOS
BARITE
BORAX
BUILDING STONE
CARBON DIOXIDE GAS
CHROMITE
CLAY
COAL
COPPER
DIATOMITE
DOLOMITE
FELDSPAR
FELDSPAR & SILICA (QUARTZ)
GOLD DISTRICTS
GOLD (SMALL AREAS OR MINES)
GYPSUM
IRON
LEAD
LIMESTONE, CEMENT & MARBLE
MAGNESITE
MANGANESE
POTASH
PUMICE & VOLCANIC ASH
PERLITE
PYRITES
QUICKSILVER
SALT
SILICA (QUARTZ)
SILICA (SAND)
SILVER
SODA
SULFUR
TALC & SOAPSTONE
TITANIUM
TUNGSTEN
ZINC
GAS DISTRICTS
OIL & GAS DISTRICTS
CITIES
NOTE
COMBINED SYMBOLS SHOW TWO OR MORE MINERALS OCCUR AT SAME LOCALITY.
BORAX, SODA
COPPER, ZINC
MATEO
SANTA CRUZ
CLARA
SAN BENITO
MERCED
MADERA
MONTEREY
SAN LUIS OBISPO
FRESNO
KINGS
TULARE
INYO
KERN
SANTA BARBARA
VENTURA
LOS ANGELES
ORANGE
SAN BERNARDINO
RIVERSIDE
SAN DIEGO
IMPERIAL
ARIZONA
MEXICO
OCEAN
DA

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CALIFORNIA MINERAL COMMODITIES IN 1952 AND 1953 †

BY HENRY H. SYMONS * AND FENELON F. DAVIS **

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PRODUCTION OF MINERALS IN CALIFORNIA DURING 1952 AND 1953

A new all-time high in the value of California mineral production was achieved during 1953 for the third successive year. Production in 1953 totaled $1,392,796,687. This figure was an increase of nearly 15 percent over the 1952 production valued at $1,214,870,000, according to tabulations compiled by the U. S. Bureau of Mines in cooperation with the California Division of Mines. The year 1953 also marked the sixth consecutive year during which mineral production in the state exceeded the billion-dollar mark.

Petroleum again led all commodities in value of production in 1953, followed by natural gas, cement, natural gasoline, sand and gravel, liquefied petroleum gases, stone, borates, iron ore, tungsten ore and concentrates, gold, and salt.

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Mineral production in California during 1952.

Commodity		Short tons (unless otherwise stated)	Value
Boron minerals		583,826	$14,105,000
Cement (including clay used for cement)—(barrels of 376 lbs. net)		29,786,245	79,457,745
Chromite		14,713	1,269,129
Clay (raw) (except for cement)		1,887,233	3,996,369
Coal		2,998	30,700
Copper	Cu content in pounds	1,600,000	387,200
Gold	Troy ounces, Au content	258,176	9,036,160
Gypsum		1,236,430	2,721,134
Iron ore	Long tons	1,463,239	*
Lead	Pb content in pounds	22,398,000	3,606,078
Lime		238,957	3,752,738
Mercury	flasks, 76 pounds Hg	7,241	1,441,683
Natural gas	thousand cubic feet	517,450,000	86,414,000
Natural gas liquids			
Natural gasoline and cycle products (bbls. of 42 gallons)		20,738,000	64,945,000
Liquefied petroleum gases (bbls. of 42 gallons)		9,376,000	16,700,000
Peat	(dry)	6,942	76,707
Petroleum (crude)	(bbls. of 42 gallons)	359,415,000	801,882,000
Pumice and pumicite		129,780	793,716
Salt		1,148,693	4,880,392
Sand and gravel		52,918,606	43,525,920
Silver	Troy ounces, Ag content	1,099,658	995,246
Stone:			
Granite (dimension stone) (cubic feet)		45,937	365,437
Limestone and dolomite[1]		1,628,462	4,160,210
Crushed stone		12,802,204	13,264,663
Talc, soapstone, and pyrophyllite (ground)		128,154	3,048,583
Tungsten (units)		178,779	11,360,569
Zinc	Zn content in pounds	18,838,000	3,127,108
Other minerals[2]			44,082,414
Total value for 1952			$1,219,425,901

[1] Except for cement and lime.

[2] Antimony, barite, bromine, calcium chloride, carbon dioxide, diatomite, feldspar, gem stones, ilmenite, iodine, iron ore, lithium minerals, magnesite, magnesium metal, magnesium compounds, manganese ore + 35%, manganiferous ore —35%, molybdenum ore, perlite (crude), platinum group metals (crude), potassium salts, pyrite, quartz, rare earths, sand and sandstone, slate, sodium carbonate, sodium sulfate, sulfur, wollastonite.

All the major fuels, petroleum, natural gas, natural gasoline and liquefied petroleum gases, registered an increase in both quantity and value of production. All-time highs in the quantity and value of production were recorded for petroleum, natural gasoline and liquefied petroleum gases. An all-time high in value of production was recorded for natural gas, but the quantity of production was below the all-time high recorded in 1948.

Each of the major structural materials of the nonmetallic group, cement, lime, sand and gravel, and stone, registered increased production with all-time highs in both quantity and value. All-time highs in value of production were recorded by clay and gypsum, although the quantity of production was below the previous year. Diatomite producton increased. A decline was reported in the quantity and value of pumice and pumicite produced during the year. Talc production also declined.

The saline group exhibited a mixed trend. Increases were recorded for the quantity and value of boron mineral produced. Salt production declined slightly although the value of the output increased 22 percent. The quantity and value of soda ash and salt cake production increased, *California mineral production in 1953.*

Mineral Commodity	Quantity	Value
Borates	715,228 short tons	$17,668,000
Cement	32,002,317 barrels (376 lbs.)	90,872,741
Chromite	1,030,422 long ton units	2,078,461
Clay, raw (except for cement)	1,534,239 short tons	4,057,074
Copper	764,000 pounds	219,268
Gold	234,591 fine ounces	8,210,685
Gypsum	1,199,489 short tons	2,855,983
Gem stones		100,000
Iron ore	1,697,652 long tons	*
Lead	17,328,000 pounds	2,269,968
Lime	301,422 short tons	4,653,303
Magnesium compounds	55,886 short tons	3,483,483
Manganese ore, over 35% Mn	8,750 short tons	443,743
Manganese ore, less than 35% Mn	8,274 short tons	317,645
Marl (calcareous)	6,028 short tons	21,102
Mercury	9,290 flasks of 76 lbs.	1,793,249
Natural gas	531,346,000 M cubic feet	104,675,000
Natural gas liquids		
Natural gasoline	21,675,000 barrels (42 gal.)	85,691,000
Liquefied petroleum gases	9,466,000 barrels (42 gal.)	21,961,000
Peat	9,196 short tons	73,897
Perlite (crude)	15,282 short tons	112,790
Petroleum	364,933,000 barrels (42 gal.)	908,680,000
Pumice and pumicite	80,814 short tons	451,499
Salt	1,123,365 short tons	6,263,059
Sand and gravel	58,453,349 short tons	53,426,685
Silver	1,036,372 short tons	937,969
Stone		
Granite (dimension stone)	37,451 cubic feet	235,025
Limestone	1,747,077 short tons	4,920,551
Miscellaneous stone	12,771,615 short tons	13,545,275
Strontium minerals	50 short tons	1,000
Talc (crude)	126,442 short tons	1,132,700
Tungsten ore	142,856 short ton units	8,906,808
Volcanic cinders	352,291 short tons	196,411
Zinc	10,716,000 pounds	1,232,340
Unapportioned*		41,308,973
Total value for 1953		$1,392,796,687

* Includes asbestos, barite, bromine, calcium chloride, carbon dioxide, coal, diatomite, feldspar, iodine, iron ore, lithium compounds, magnesite, marl (calcareous), molybdenum con., platinum group metals, potash salts, pyrite, rare earth materials, slate, sodium carbonate, sodium sulfate, strontium minerals, sulfur.

and the value of potash salts production increased. Declines in value of production were registered by bromine, calcium chloride, and lithium salts.

The metal group also exhibited a mixed trend. Increases in production and value of strategic metals were reported for chromite, iron ore, manganese ore and concentrates, and mercury. The precious metals, gold and silver, and the associated base metals, copper, lead and zinc, all registered a decrease in quantity and value of production.

In 1952, a total of $1,219,425,901 worth of mineral commodities was produced, as compiled by the U. S. Bureau of Mines in cooperation with the California Division of Mines. This figure was an increase of about 1 percent over the 1951 production valued at $1,209,428,000, and marked the fifth consecutive year during which mineral production in the state exceeded the billion-dollar mark.

Petroleum led all commodities in value of production, followed by natural gas, cement, natural gasoline, sand and gravel, miscellaneous stone, liquid petroleum gases, borates, tungsten ore and concentrates, iron ore and gold.

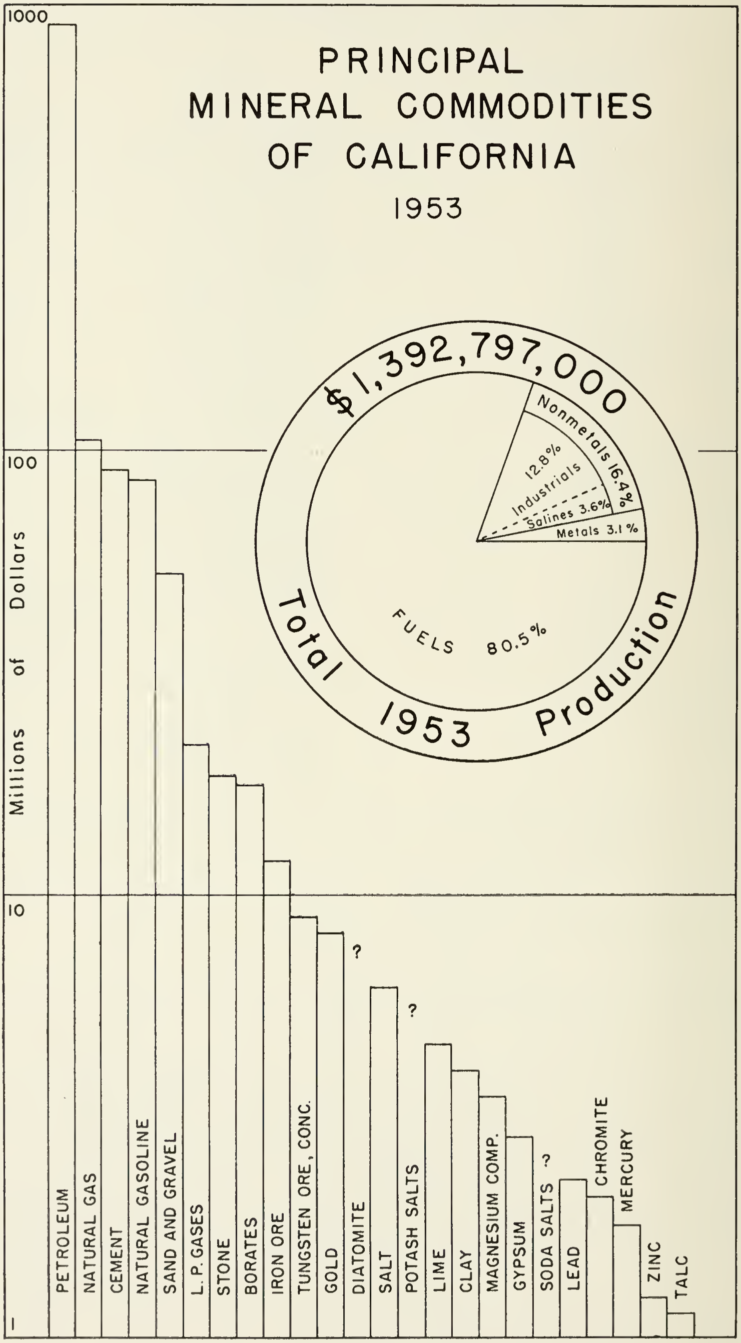
PRINCIPAL MINERAL COMMODITIES OF CALIFORNIA
1953
Millions of Dollars
1000
100
10
1
$1,392,797,000
Total 1953 Production
Nonmetals 16.4%
12.8% Industrials
Salines 3.6%
Metals 3.1%
FUELS 80.5%
PETROLEUM
NATURAL GAS
CEMENT
NATURAL GASOLINE
SAND AND GRAVEL
L. P. GASES
STONE
BORATES
IRON ORE
TUNGSTEN ORE, CONC.
GOLD
DIATOMITE ?
SALT
POTASH SALTS ?
LIME
CLAY
MAGNESIUM COMP.
GYPSUM
SODA SALTS ?
LEAD
CHROMITE
MERCURY
ZINC
TALC

FIGURE 1.

MINERAL PRODUCTION IN COUNTIES OF CALIFORNIA IN 1953

Excepting San Francisco, all counties in the state contributed to the value of mineral production during the year. Los Angeles County was the chief producer, followed by Kern, Ventura, Fresno, Orange, and Santa Barbara Counties. These six counties are the locus of the principal oil fields of the state and fuels accounted for most of their valuation.

Ranking behind the principal oil-producing counties were: San Bernardino, Riverside, Santa Clara, Sacramento, Monterey, Kings, Alameda, San Luis Obispo, Inyo, Solano, and Calaveras Counties.

The desert county of San Bernardino produced the most diversified mineral commodities. Substantial items were: cement, potassium salts, borates, sodium salts, talc, limestone, tungsten ore and concentrates and rare earth minerals. Riverside, another desert county, produced iron ore, cement, clay, gypsum and manganese ore. A county of the Coast Ranges, Santa Clara, was the principal producer of cement. Sacramento, a county in the Great Valley, was the principal producer of dry gas. It is also the site of large dredging operations and consequently the principal producer of placer gold.

Monterey, Kings and San Luis Obispo are oil-producing counties. Alameda is the principal producer of salt from solar evaporation. Inyo County is chief producer of tungsten concentrates. Solano County produces dry gas. Calaveras County produces cement and lode gold.

Value of mineral output in California for 1953 by counties.

County	Value	County	Value
Alameda	$13,997,116	Sacramento	$23,241,371
Alpine	*	San Benito	4,936,676
Amador	473,539	San Bernardino	60,835,343
Butte	1,442,486	San Diego	5,376,292
Calaveras	8,090,472	San Francisco	0
Colusa	111,341	San Joaquin	2,844,736
Contra Costa	1,625,021	San Luis Obispo	12,744,161
Del Norte	477,811	San Mateo	7,941,478
El Dorado	1,992,069	Santa Barbara	96,970,587
Fresno	117,435,674	Santa Clara	23,535,766
Glenn	336,864	Santa Cruz	6,378,618
Humboldt	1,203,419	Shasta	911,585
Imperial	2,291,222	Sierra	760,584
Inyo	11,818,612	Siskiyou	1,084,668
Kern	284,034,865	Solano	10,922,549
Kings	20,025,714	Sonoma	2,232,884
Lake	324,729	Stanislaus	494,547
Lassen	103,356	Sutter	209,124
Los Angeles	320,298,125	Tehama	190,702
Madera	1,296,913	Trinity	308,886
Marin	1,041,683	Tulare	1,834,047
Mariposa	223,006	Tuolumne	972,399
Mendocino	268,974	Ventura	163,643,504
Merced	956,066	Yolo	1,653,858
Modoc	146,002	Yuba	1,957,386
Mono	1,640,749		
Monterey	22,382,023		
Napa	648,026		
Nevada	2,509,121	*Not segregated by counties	
Orange	117,602,571	(includes Alpine County)	921,295
Placer	953,927		
Plumas	94,967	Total value	$1,392,796,687
Riverside	24,047,178		

Mineral production for 1953 by counties.

Alameda County

Product		Quantity	Value
Clay (raw)	short tons	11,690	$12,590
Sand and gravel	short tons	5,598,583	6,029,133
Crushed stone	short tons	1,179,307	1,181,338
Other minerals*			6,774,055
Total value			$13,997,116

---

* Includes chromite, magnesium compounds, bromine, and salt; not included is synthetic gypsum produced as a byproduct from recovery of magnesium salts.

Alpine County

Mineral output included sand and gravel, sulfur, and tungsten ore.

Amador County

Clay (raw)	short tons	117,021	$324,243
Gold	fine ounces	3,253	113,890
Sand and gravel	short tons	35,762	10,765
Silver	fine ounces	708	641
Other minerals			24,000
Total value			$473,539

Butte County

Gold	fine ounces	197	$6,895
Natural gas	M cubic feet	3,401,365	693,334
Sand and gravel	short tons	340,758	478,224
Silver	fine ounces	22	20
Stone (crushed)	short tons	248,023	210,359
Other minerals			53,654
Total value			$1,442,486

Calaveras County

Copper	pounds	56,000	$16,072
Gold	fine ounces	936	32,760
Lead	pounds	4,100	537
Silver	fine ounces	1,694	1,533
Zinc	pounds	61,200	7,038
Other minerals*			8,032,532
Total value			$8,090,472

---

* Includes cement, clay (raw), pumice, sand and gravel, and tungsten concentrates.

Colusa County

Mineral output was 201,627 tons of sand and gravel worth $111,341.

Contra Costa County

Sand and gravel	short tons	84,242	$55,771
Stone (crushed)	short tons	945,603	1,236,269
Other minerals*			332,981
Total value			$1,625,021

---

* Includes clay (raw), peat, and natural gas.

Mineral production for 1953 by counties—continued.

Del Norte County

Product		Quantity	Value
Chromite	long ton units	147,329	$310,012
Gold	fine ounces	5	175
Silver	fine ounce	1	1
Sand and gravel	short tons	144,193	146,601
Stone (crushed)	short tons	18,900	20,250
Other minerals			772
Total value			$477,811

El Dorado County

Chromite	long ton units	27,876	$55,426
Copper	pounds	158,000	45,346
Gold	fine ounces	7,431	260,085
Lead	pounds	38,000	4,978
Sand and gravel	short tons	93,437	74,312
Silver	fine ounces	2,934	2,655
Stone (crushed)	short tons	26,387	39,460
Zinc	pounds	19,900	2,288
Other minerals*			1,507,519
Total value			$1,992,069

---

* Includes lime, limestone, slate, and soapstone.

Fresno County

Gold	fine ounces	170	$5,950
Natural gas	M cubic feet	42,079,823	8,928,917
Natural gas liquids			
Natural gasoline	barrels	1,387,000	5,940,000
Liquefied petroleum gases	barrels	1,293,000	3,284,000
Petroleum	barrels	35,721,975	97,874,100
Sand and gravel	short tons	927,764	698,451
Silver	fine ounces	23	21
Stone (crushed)	short tons	500,414	403,893
Other minerals*			300,342
Total value			$117,435,674

---

* Includes chromite, clay (raw), gypsum, marl (calcareous), mercury, granite, and tungsten concentrates.

Glenn County

Sand and gravel	short tons	298,774	$196,147
Other minerals			140,717
Total value			$336,864

Humboldt County

Gold	fine ounces	10	$350
Sand and gravel	short tons	791,955	755,299
Stone (crushed)	short tons	26,476	72,798
Other minerals*			374,972
Total value			$1,203,419

---

* Includes clay (raw), manganese ore, natural gas, and petroleum.

Mineral production for 1953 by counties—continued.

Imperial County

Product		Quantity	Value
Gold	fine ounces	5	$175
Sand and gravel	short tons	508,066	370,049
Silver	fine ounce	1	1
Stone (crushed)	short tons	27,518	35,481
Other minerals*			1,885,516
Total value			$2,291,222

* Includes gypsum, manganese ore, carbon dioxide, pumice and strontium minerals.

Inyo County

Product		Quantity	Value
Copper	pounds	302,100	$86,703
Gold	fine ounces	970	33,950
Lead	pounds	17,262,500	2,261,388
Sand and gravel	short tons	126,579	88,569
Silver	fine ounces	987,468	893,708
Talc	short tons	55,733	382,171
Tungsten concentrates	units	91,319	5,712,003
Zinc	pounds	10,625,200	1,221,898
Other minerals*			1,138,222
Total value			$11,818,612

* Includes borates, clay (raw, bentonite and fullers earth), diatomite, manganese ores, molybdenum conc., perlite, pumice and pumicite, sodium carbonate, sulfur.

Kern County

Product		Quantity	Value
Clay (raw)	short tons	68,324	$599,704
Gold	fine ounces	3,009	105,315
Gypsum	short tons	249,502	433,018
Lead	pounds	4,200	550
Natural gas	M cubic feet	94,344,606	18,222,198
Natural gas liquids			
Natural gasoline	barrels	5,659,000	22,261,000
Liquefied petroleum gases	barrels	2,850,000	7,213,000
Petroleum	barrels	93,580,090	217,068,760
Sand and gravel	short tons	555,714	628,928
Silver	fine ounces	3,858	3,492
Tungsten concentrates	units	607	37,968
Other minerals*			17,460,932
Total value			$284,034,865

* Includes borates, cement, limestone, pumice, salt, silica (quartz).

Kings County

Product		Quantity	Value
Natural gas	M cubic feet	28,745,643	$6,036,564
Petroleum	barrels	2,991,435	9,333,236
Other minerals*			4,655,914
Total value			$20,025,714

* Includes gypsum, natural gas liquids, and sand and gravel.

Lake County

Product		Quantity	Value
Sand and gravel	short tons	111,323	$71,543
Other minerals*			253,186
Total value			$324,729

* Includes chromite, manganese ore, and mercury.

Mineral production for 1953 by counties—continued.

Lassen County

Product		Quantity	Value
Sand and gravel	short tons	146,887	$84,422
Other minerals			18,934
Total value			$103,356

Los Angeles County

Product		Quantity	Value
Clay (raw)	short tons	420,922	$428,671
Gold	fine ounces	158	5,530
Natural gas	M cubic feet	93,302,408	16,309,874
Natural gas liquids			
Natural gasoline	barrels	6,377,000	25,485,000
Liquefied petroleum gases	barrels	1,084,000	2,175,000
Petroleum	barrels	97,341,900	254,678,280
Sand and gravel	short tons	19,819,526	14,969,723
Silver	fine ounces	29	26
Stone (crushed)	short tons	3,090,102	2,820,052
Other minerals*			3,425,969
Total value			$320,298,125

---

* Includes cement, diatomite, iodine, and soapstone.

Madera County

Product		Quantity	Value
Copper	pounds	102,800	$29,504
Gold	fine ounces	376	13,160
Natural gas	M cubic feet	2,830,648	600,635
Silver	fine ounces	1,058	958
Other minerals*			652,656
Total value			$1,296,913

---

* Includes granite, pumice and pumicite, sand and gravel, crushed stone, and tungsten concentrates.

Marin County

The mineral production had a total value of $1,041,683 which included raw clay, sand and gravel, and crushed stone.

Mariposa County

Product		Quantity	Value
Gold	fine ounces	691	$24,185
Sand and gravel	short tons	27,903	50,028
Silver	fine ounces	129	117
Other minerals			148,676
Total value			$223,006

Mendocino County

Product		Quantity	Value
Sand and gravel	short tons	189,956	$264,076
Other minerals			4,898
Total value			$268,974

Merced County

Product		Quantity	Value
Gold	fine ounces	9	$315
Sand and gravel	short tons	950,504	877,347
Other minerals			78,404
Total value			$956,066

Mineral production for 1953 by counties—continued.

Modoc County

Product		Quantity	Value
Gold	fine ounces	12	$420
Pumice and volcanic cinders	short tons	11,085	31,771
Sand and gravel	short tons	340,693	110,676
Silver	fine ounces	6	5
Other minerals			3,130
Total value			$146,002

Mono County

Product		Quantity	Value
Gold	fine ounces	176	$6,160
Lead	pounds	3,300	432
Silver	fine ounces	2,336	2,114
Tungsten concentrates	units	23,179	1,449,846
Zinc	pounds	4,000	181,460
Other minerals*			181,737
Total value			$1,640,749

---

* Includes clay (raw), pumice, pyrophyllite, sand and gravel, crushed stone.

Monterey County

Product		Quantity	Value
Gold	fine ounces	4	$140
Petroleum	barrels	11,320,075	13,707,137
Sand and gravel	short tons	1,114,261	2,786,154
Silver	fine ounces	3	3
Stone	short tons	57,293	62,125
Other minerals*			5,826,464
Total value			$22,382,023

---

* Includes dolomite, feldspar, lime, magnesium compounds, natural gas, sand and sandstone (ground), and silica sand.

Napa County

Product		Quantity	Value
Sand and gravel	short tons	5,703	$3,058
Other minerals*			644,968
Total value			$648,026

---

* Includes chromite, diatomite, mercury, perlite, crushed stone.

Nevada County

Product		Quantity	Value
Copper	pounds	9,300	$2,669
Gold	fine ounces	70,289	2,459,765
Sand and gravel	short tons	61,327	30,324
Silver	fine ounces	18,080	16,363
Total value			$2,509,121

Orange County

Product		Quantity	Value
Clay (raw)	short tons	47,313	$178,981
Natural gas	M cubic feet	32,702,054	5,559,349
Natural gas liquids			
Natural gasoline	barrels	3,090,000	12,818,000
Liquefied petroleum gases	barrels	1,182,000	2,604,000
Petroleum	barrels	37,532,360	93,136,550
Sand and gravel	short tons	3,003,406	2,629,786
Other minerals*			675,905
Total value			$117,602,571

---

* Includes clay (raw), peat, salt, and crushed stone.

Mineral production for 1953 by counties—continued.

Placer County

Product		Quantity	Value
Chromite	long ton units	1,563	$3,697
Gold	fine ounces	533	18,655
Sand and gravel	short tons	1,029,943	532,043
Silver	fine ounces	67	61
Other minerals*			399,471
Total value			$953,927

* Includes asbestos (amphibole), clay (raw), granite, and crushed stone.

Plumas County

Gold	fine ounces	206	$7,210
Manganese ore	long tons	403	18,784
Silver	fine ounces	31	28
Other minerals*			68,945
Total value			$94,967

* Includes barite, sand and gravel, and crushed stone.

Riverside County

Clay (raw)	short tons	225,934	$1,063,611
Copper	pounds	600	172
Gold	fine ounces	14	490
Lead	pounds	2,100	275
Manganese ore and concentrates	long tons	2,149	106,510
Sand and gravel	short tons	803,469	1,168,394
Silver	fine ounces	64	58
Other minerals*			21,707,668
Total value			$24,047,178

* Includes cement, gypsum, iron ore, limestone, crushed rock, talc.

Sacramento County

Clay (raw)	short tons	19,493	$33,043
Gold	fine ounces	64,811	2,281,650
Natural gas	M cubic feet	61,504,310	15,745,103
Sand and gravel	short tons	6,551,061	4,704,063
Silver	fine ounces	2,786	2,521
Other minerals			474,991
Total value			$23,241,371

San Benito County

Mercury	flasks	4,119	$795,091
Other minerals*			4,141,585
Total value			$4,936,676

* Includes cement, bentonite, manganese ore, natural gas, petroleum, sand and gravel, dolomite, and crushed stone.

San Bernardino County

Clay (raw, including bentonite)	short tons	41,930	$353,850
Copper	pounds	76,400	22,501
Gold	fine ounces	690	24,150
Lead	pounds	11,200	1,467
Manganese ore and conentrates	long tons	1,843	136,935
Sand and gravel	short tons	2,168,881	2,173,938
Limestone	short tons	212,014	1,241,216
Stone crushed	short tons	333,478	330,361
Silver	fine ounces	3,395	3,073
Talc	short tons	48,594	679,674
Zinc	pounds	5,600	644
Other minerals*			55,867,534
Total value			$60,835,343

* Includes barite, borates, bromine, calcium chloride, cement, feldspar, granite, gypsum, iron ore, lime, lithium compounds, natural gas, perlite, petroleum, potash, pumice, rare earths, silica (quartz), sodium carbonate, sodium sulfate, tungsten concentrates.

Mineral production for 1953 by counties—continued.

San Diego County

Product		Quantity	Value
Granite	cubic feet	17,692	$54,075
Sand and gravel	short tons	3,100,522	4,287,389
Stone (crushed)	short tons	340,169	562,359
Tungsten ore	units	145	9,071
Other minerals*			463,398
Total value			$5,376,292

* Includes clay (raw), gold, magnesium chloride, salt, and silver.

San Joaquin County

Natural gas	M cubic feet	4,396,924	$984,735
Sand and gravel	short tons	1,664,436	1,552,198
Other minerals			307,803
Total value			$2,844,736

San Luis Obispo County

Chromite	long ton units	399,452	$733,574
Natural gas	M cubic feet	1,287,649	193,347
Petroleum	barrels	3,263,843	10,014,940
Sand and gravel	short tons	264,415	188,620
Other minerals*			1,613,680
Total value			$12,744,161

* Includes gypsum, manganese ore, mercury, limestone, and natural gas liquids.

San Mateo County

The mineral production of San Mateo County was valued at $7,941,478 and included cement, gold, limestone, magnesium compounds, sand, and crushed stone.

Santa Barbara County

Natural gas	M cubic feet	23,155,454	$3,589,095
Natural gas liquids			
Natural gasoline	barrels	1,003,000	3,858,000
Liquefied petroleum gases	barrels	525,000	1,025,000
Petroleum	barrels	35,374,550	81,167,250
Sand and gravel	short tons	371,285	522,922
Other minerals*			6,808,320
Total value			$96,970,587

* Includes chromite, clay (raw), diatomite, and crushed stone.

Santa Clara County

Clay (raw)	short tons	17,245	$14,751
Mercury	flasks	175	35,324
Sand and gravel	short tons	1,038,679	729,125
Stone crushed	short tons	928,073	547,570
Other minerals*			22,208,996
Total value			$23,535,766

* Includes cement, chromite, limestone, magnesite, and petroleum.

Santa Cruz County

Sand and gravel	short tons	648,371	$620,038
Other minerals*			5,758,580
Total value			$6,378,618

* Includes cement, limestone, potash, stone (crushed).

Mineral production for 1953 by counties—continued.

Shasta County

Product		Quantity	Value
Chromite	long ton units	2,976	$4,876
Sand and gravel	short tons	259,259	260,355
Other minerals*			646,354
Total value			$911,585

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* Includes copper, gold, iron ore, pyrite, and stone (crushed).

Sierra County

Product		Quantity	Value
Copper	pounds	900	$258
Gold	fine ounces	21,586	755,510
Silver	fine ounces	5,321	4,816
Total value			$760,584

Siskiyou County

Product		Quantity	Value
Chromite	long ton units	206,768	$467,224
Gold	fine ounces	3,865	135,345
Lead	pounds	1,100	144
Pumice and volcanic cinders	short tons	344,395	197,606
Sand and gravel	short tons	186,411	242,809
Silver	fine ounces	2,144	1,940
Stone (crushed)	short tons	33,325	37,955
Other minerals			1,645
Total value			$1,084,668

Solano County

Product		Quantity	Value
Natural gas	M cubic feet	40,712,320	$10,442,303
Other minerals			480,246
Total value			$10,922,549

Sonoma County

Mineral production of Sonoma County included chromite, manganese ore, mercury, natural gas, petroleum, sand and gravel, and stone (crushed).

Total value	$2,232,884

Stanislaus County

Product		Quantity	Value
Sand and gravel	short tons	539,607	$475,118
Other minerals			19,429
Total value			$494,547

Sutter County

Mineral production of Sutter County included clay (raw), natural gas, and sand and gravel.

Total value	$209,124

Tehama County

Product		Quantity	Value
Chromite	long ton units	43,982	$97,946
Sand and gravel	short tons	71,138	75,623
Stone (crushed)	short tons	9,441	17,133
Total value			$190,702

Mineral production for 1953 by counties—continued.

Trinity County

Product		Quantity	Value
Chromite	long ton units	9,589	$22,251
Gold	fine ounces	5,697	199,395
Manganese ore	long tons	583	43,055
Sand and gravel	short tons	35,747	43,656
Silver	fine ounces	585	529
Total value			$308,886

Tulare County

Natural gas	M cubic feet	4,871,897	$1,065,502
Tungsten concentrates	units	4,002	250,325
Other minerals			518,220
Total value			$1,834,047

* Includes clay (raw), lead, petroleum, sand and gravel, silver, zinc, stone (crushed).

Tuolumne County

Gold	fine ounces	95	$3,115
Silver	fine ounces	34	31
Stone (crushed)	short tons	18,045	10,346
Other minerals*			958,907
Total value			$972,399

* Includes asbestos (chrysotile), lime, limestone, sand and gravel, marble, tungsten ore.

Ventura County

Natural gas	M cubic feet	89,379,655	$14,658,265
Natural gasoline	barrels	3,363,000	12,170,000
Liquefied petroleum gases	barrels	1,434,000	3,148,000
Petroleum	barrels	47,751,720	131,568,000
Sand and gravel	short tons	910,238	1,146,794
Other minerals			952,445
Total value			$163,643,504

* Includes clay (raw), gypsum, limestone and stone (crushed).

Yolo County

Natural gas	M cubic feet	3,553,100	$624,228
Sand and gravel	short tons	1,203,039	1,022,846
Other minerals			6,784
Total value			$1,653,858

Yuba County

Gold	fine ounces	48,852	$1,709,820
Silver	fine ounces	3,421	3,096
Other minerals			244,470
Total value			$1,957,386

MINERAL PRODUCTION IN COUNTIES OF CALIFORNIA IN 1952

All counties excepting San Francisco contributed to the value of mineral production. Los Angeles County was the principal producer, followed by Kern, Ventura, Fresno, Orange, Santa Barbara, San Bernardino, Riverside, Santa Clara, Sacramento, Inyo, Kings, Monterey, Alameda, and Solano Counties.

Mineral production in each of the 10 leading counties was valued in excess of $20,000,000. The six leading counties were producers of petroleum and natural gas. San Bernardino County in seventh place produced the most diversified list of minerals. The list included 30 mineral commodities and the principal items were: cement, potassium salts, borates, soda ash, salt cake, talc (including soapstone and pyrophyllite), sand and gravel, limestone, tungsten ore and concentrates, salt, and rare earth minerals.

The principal products of Riverside County, in eighth place were: iron ore, cement, sand and gravel, clay, gypsum, and manganese ore. Santa Clara County produced cement from the largest mill in the world. Sacramento in 10th place, produced natural gas and was the leading gold producer in the state. The gold came from the placer deposits of the large dredging companies. Inyo County was the principal producer of lead, zinc, and tungsten. Kings and Monterey Counties were petroleum producers. Alameda County was the leading salt producer (from solar evaporation in the southern end of San Francisco Bay).

Value of mineral output in California for 1952 by counties.

County	Value	County	Value
Alameda	$12,549,189	Sacramento	$20,875,032
Alpine	54,767	San Benito	4,064,354
Amador	886,590	San Bernardino	53,351,806
Butte	1,332,765	San Diego	4,289,328
Calaveras	5,303,007	San Francisco	0
Colusa	151,181	San Joaquin	3,772,259
Contra Costa	1,240,409	San Luis Obispo	10,705,420
Del Norte	585,519	San Mateo	7,930,052
El Dorado	1,984,027	Santa Barbara	83,872,115
Fresno	112,590,836	Santa Clara	21,406,741
Glenn	339,976	Santa Cruz	5,415,332
Humboldt	819,541	Shasta	2,488,653
Imperial	1,593,994	Sierra	493,662
Inyo	18,714,386	Siskiyou	590,334
Kern	242,510,003	Solano	11,066,132
Kings	17,928,854	Sonoma	1,584,611
Lake	213,271	Stanislaus	372,225
Lassen	36,725	Sutter	245,501
Los Angeles	280,983,199	Tehama	33,468
Madera	940,145	Trinity	298,461
Marin	1,159,268	Tulare	1,977,193
Mariposa	323,980	Tuolumne	819,109
Mendocino	220,294	Ventura	125,135,260
Merced	507,550	Yolo	1,358,415
Modoc	112,371	Yuba	1,982,862
Mono	590,364		
Monterey	15,521,463	Total	$1,213,446,392
Napa	920,656		
Nevada	2,706,372		
Orange	103,713,804		
Placer	452,262	Not segregated by counties	5,979,509
Plumas	102,623		
Riverside	22,328,676	Total value	$1,219,425,901

Mineral production in California in 1952 by counties.

Alameda County

Product		Quantity	Value
Clay	short tons	13,810	$12,650
Sand and gravel	short tons	5,758,892	6,023,956
Stone, misc.	short tons	1,166,824	1,129,231
Unapportioned: Bromine, magnesium compounds, natural gas, pumice, salt			5,383,352
Total value			$12,549,189

Alpine County

Mineral production consisted of sand and gravel and tungsten concentrates.

Amador County

Clay	short tons	165,979	$547,319
Gold	troy ounces	6,901	241,535
Silver	troy ounces	1,497	1,355
Unapportioned: coal, sand and gravel, stone (misc.)			96,381
Total value			$886,590

Butte County

Chromite	long tons	1,229	$36,349
Gold	troy ounces	8,572	300,125
Sand and gravel	short tons	425,874	424,079
Silver	troy ounces	797	721
Unapportioned: natural gas, platinum, stone (misc.)			571,491
Total value			$1,332,765

Calaveras County

Copper	pounds	528,500	$127,897
Gold	troy ounces	1,877	65,695
Lead	pounds	93,800	15,102
Silver	troy ounces	39,307	35,330
Zinc	pounds	1,658,400	275,294
Unapportioned: cement, clay, pumice, sand and gravel			4,783,689
Total value			$5,303,007

Colusa County

Mineral production consisted of sand and gravel.

Contra Costa County

Clay	short tons	61,888	$82,720
Sand and gravel	short tons	179,824	126,501
Unapportioned: natural gas, peat, mercury, stone (misc.)			1,031,188
Total value			$1,240,409

Del Norte County

Chromite	long tons	4,625	$484,637
Mercury	flasks	1	199
Sand and gravel	short tons	108,288	95,483
Stone (misc.)	short tons	13,000	5,200
Total value			$585,519

Mineral production in California in 1952 by counties—continued

El Dorado County

Product		Quantity	Value
Gold	troy ounces	5,905	$206,675
Lead	pounds	28,700	4,621
Silver	troy ounces	2,101	1,901
Limestone	short tons	166,106	498,927
Unapportioned: chromite, lime, sand and gravel, slate, stone (misc.), soapstone (ground)			1,271,903
Total value			$1,984,027

Fresno County

Product		Quantity	Value
Gold	troy ounces	277	$9,695
Natural gas	thousand cubic feet	40,785,112	6,523,674
Petroleum	barrels	38,523,498	95,259,073
Sand and gravel	short tons	2,916,540	1,962,310
Silver	troy ounces	44	40
Stone (misc.)	short tons	333,327	398,407
Unapportioned: chromite, clay, gypsum, natural gasoline, liquefied petroleum gases, mercury, granite, tungsten			8,437,637
Total value			$112,590,836

Glenn County

Mineral production consisted of sand and gravel and natural gas.

Humboldt County

Product		Quantity	Value
Sand and gravel	short tons	757,521	$428,362
Unapportioned: clay, natural gas, stone (misc.)			391,179
Total value			$819,541

Imperial County

Product		Quantity	Value
Gold	troy ounces	412	$14,420
Lead	pounds	300	48
Sand and gravel	short tons	325,777	104,987
Silver	troy ounces	182	165
Unapportioned: carbon dioxide, gypsum, manganese oxide, pumice, stone, misc.			1,474,374
Total value			$1,593,994

Inyo County

Product		Quantity	Value
Copper	pounds	319,000	$77,198
Gold	troy ounces	2,764	96,740
Lead	pounds	20,918,700	3,367,911
Sand and gravel	short tons	71,283	36,926
Silver	troy ounces	856,523	775,197
Zinc	pounds	11,754,700	1,951,280
Unapportioned: borates, clay, diatomite, molybdenite, crude perlite, pumice, soda ash and trona, sulfur, talc (ground), tungsten			12,409,134
Total value			$18,714,386

Mineral production in California in 1952 by counties—continued

Kern County

Product		Quantity	Value
Clay	short tons	122,406	$831,901
Copper	pounds	800	194
Gold	troy ounces	9,790	342,650
Gypsum	short tons	552,739	848,272
Lead	pounds	200	32
Natural gas	thousand cubic feet	71,505,994	10,445,036
Natural gasoline	barrels	5,323,000	17,105,000
Liquefied petroleum gases	barrels	3,475,000	6,619,000
Petroleum	barrels	89,962,498	190,506,712
Sand and gravel	short tons	860,789	722,589
Silver	troy ounces	45,393	41,083
Unapportioned: antimony ore, borates, cement, pumicite, salt, tungsten ore			15,047,534
Total value			$242,510,003

Kings County

Natural gas	thousand cubic feet	27,770,240	$4,336,215
Petroleum	barrels	3,529,129	9,523,660
Unapportioned: gypsum, natural gasoline, liquefied petroleum gases, sand and gravel, limestone			4,068,979
Total value			$17,928,854

Lake County

Mercury	flasks	599	$119,261
Sand and gravel	short tons	137,193	93,422
Other minerals			588
Total value			$213,271

Lassen County

Mineral production consisted of sand, gravel and granite.

Los Angeles County

Clay	short tons	566,557	$615,462
Natural gas	thousand cubic feet	101,956,302	13,855,874
Natural gasoline	barrels	6,284,000	19,527,000
Liquefied petroleum gases	barrels	1,097,000	1,495,000
Petroleum	barrels	98,385,523	226,241,151
Sand and gravel	short tons	15,204,792	11,330,512
Stone, misc.	short tons	3,871,159	3,352,808
Unapportioned: cement, diatomite, gold, iodine, silver, titanium ore, soapstone (ground)			4,565,392
Total value			$280,983,199

Madera County

Copper	pounds	37,000	$8,954
Gold	troy ounces	225	7,875
Natural gas	thousand cubic feet	3,043,308	459,872
Sand and gravel	short tons	100,275	17,200
Silver	troy ounces	362	329
Unapportioned: pumice, pumicite, tungsten ore			445,915
Total value			$940,145

Mineral production in California in 1952 by counties—continued

Marin County

Product		Quantity	Value
Sand and gravel	short tons	31,102	$25,633
Unapportioned: clay and stone (misc.)			1,133,635
Total value			$1,159,268

Mariposa County

Product		Quantity	Value
Gold	troy ounces	666	$23,310
Lead	pounds	4,300	692
Sand and gravel	short tons	101,974	144,687
Silver	troy ounces	368	333
Unapportioned: quartz and soapstone (ground)			154,958
Total value			$323,980

Mendocino County

Product		Quantity	Value
Sand and gravel	short tons	165,674	$220,294
Total value			$220,294

Merced County

Product		Quantity	Value
Sand and gravel	short tons	473,463	$487,387
Unapportioned: gold, gypsum, silver			20,163
Total value			$507,550

Modoc County

Product		Quantity	Value
Gold	troy ounces	75	$2,625
Pumice	short tons	18,525	51,400
Sand and gravel	short tons	180,736	44,283
Silver	troy ounces	70	63
Unapportioned			14,000
Total value			$112,371

Mono County

Product		Quantity	Value
Sand and gravel	short tons	24,156	$13,894
Unapportioned: clay, gold, lead, pumice, silver, pyrophyllite (ground) tungsten ore, zinc			576,470
Total value			$590,364

Monterey County

Product		Quantity	Value
Petroleum	barrels	8,286,585	$9,198,100
Sand and gravel	short tons	815,752	1,695,815
Unapportioned: chromite, feldspar, lime, magnesium compounds, natural gas, salt, silica sand, dolomite, stone (misc.)			4,627,548
Total value			$15,521,463

Napa County

Product		Quantity	Value
Mercury	flasks	41	$8,163
Sand and gravel	short tons	76,561	128,604
Unapportioned: perlite (crude), pumice, stone			783,889
Total value			$920,656

Mineral production in California in 1952 by counties—continued

Nevada County

Product		Quantity	Value
Copper	pounds	800	$194
Gold	troy ounces	75,919	2,657,165
Silver	troy ounces	22,519	20,381
Other minerals			28,632
Total value			$2,706,372

Orange County

Clay	short tons	21,871	$76,795
Natural gas	thousand cubic feet	32,712,511	4,943,164
Natural gasoline	barrels	2,839,000	8,996,000
Liquefied petroleum gases	barrels	386,000	581,000
Petroleum	barrels	38,317,601	86,972,606
Sand and gravel	short tons	2,294,243	1,846,451
Stone (misc.)	short tons	253,845	235,081
Unapportioned: peat, salt			62,707
Total value			$103,713,804

Placer County

Gold	troy ounces	533	$19,355
Clay	short tons	121,560	252,020
Sand and gravel	short tons	215,150	60,990
Silver	troy ounces	59	53
Unapportioned: chromite, granite, stone (misc.)			119,844
Total value			$452,262

Plumas County

Gold	troy ounces	108	$3,780
Sand and gravel	short tons	113,062	51,590
Silver	troy ounces	7	6
Unapportioned: barite, manganese ore, stone (misc.)			47,247
Total value			$102,623

Riverside County

Clay	short tons	195,692	$594,288
Copper	pounds	2,200	532
Gold	troy ounces	33	1,155
Lead	pounds	12,200	1,964
Sand and gravel	short tons	1,247,036	1,583,994
Silver	troy ounces	427	386
Unapportioned: cement, gypsum, manganese ore, limestone, stone (misc.) wollastonite, iron ore			20,146,357
Total value			$22,328,676

Sacramento County

Gold	troy ounces	73,354	$2,567,390
Natural gas	thousand cubic feet	64,340,787	15,555,970
Sand and gravel	short tons	5,667,454	2,017,177
Silver	troy ounces	3,127	2,830
Unapportioned: clay, platinum, stone (misc.)			731,665
Total value			$20,875,032

Mineral production in California in 1952 by counties—continued

San Benito County

Product		Quantity	Value
Mercury	flasks	3,129	$622,984
Sand and gravel	short tons	48,081	33,000
Unapportioned: cement, clay, petroleum, dolomite, stone (misc.)			3,408,370
Total value			$4,064,354

San Bernardino County

Clay	short tons	23,616	$247,492
Copper	pounds	77,900	18,852
Gold	troy ounces	668	23,380
Lead	pounds	120,000	19,320
Sand and gravel	short tons	1,474,462	1,268,155
Silver	troy ounces	7,014	6,348
Limestone	tons	209,234	971,683
Zinc	pounds	12,600	2,092
Unapportioned: borates, bromine, calcium chloride, cement, feldspar, lithium minerals, lime, perlite (crude), petroleum, pumice, pumicite, potash, salt, quartz, rare earths, soda ash, salt cake, granite, stone, talc and pyrophyllite (ground), tungsten ore, iron ore			50,794,484
Total value			$53,351,806

San Diego County

Sand and gravel	short tons	2,653,414	$3,302,871
Granite	cubic feet	28,937	113,597
Unapportioned: clay, magnesium salts, salt, limestone, stone (misc.)			872,860
Total value			$4,289,328

San Joaquin County

Natural gas	thousand cubic feet	6,166,095	$1,490,805
Sand and gravel	short tons	2,043,938	1,823,755
Unapportioned: clay, manganese ore, stone (misc.)			457,699
Total value			$3,772,259

San Luis Obispo County

Natural gas	thousand cubic feet	2,456,493	$462,804
Petroleum	barrels	3,362,209	8,561,062
Sand and gravel	short tons	237,795	199,410
Unapportioned: chromite, gypsum, natural gasoline, liquefied petroleum gases, mercury, limestone			1,482,144
Total value			$10,705,420

San Mateo County

Gold	troy ounces	3	$105
Sand and gravel	short tons	329,667	360,669
Silver	troy ounces	1	1
Unapportioned: cement, magnesium salts, platinum, limestone, stone (misc.)			7,569,277
Total value			$7,930,052

Mineral production in California in 1952 by counties—continued

Santa Barbara County

Product		Quantity	Value
Natural gas	thousand cubic feet	26,146,129	$3,476,809
Natural gasoline	barrels	819,000	2,517,000
Liquefied petroleum gases	barrels	667,000	976,000
Petroleum	barrels	36,992,186	73,265,854
Sand and gravel	short tons	408,836	559,919
Unapportioned: chromite, clay, diatomite, limestone			3,076,533
Total value			$83,872,115

Santa Clara County

Clay	short tons	55,511	$45,792
Sand and gravel	short tons	781,050	595,212
Unapportioned: cement, magnesite, mercury, petroleum, limestone, stone (misc.)			20,765,737
Total value			$21,406,741

Santa Cruz County

Sand and gravel	short tons	660,646	$641,174
Unapportioned: cement, limestone, stone (misc.)			4,774,158
Total value			$5,415,332

Shasta County

Copper	pounds	633,700	$153,355
Gold	troy ounces	750	25,900
Lead	pounds	1,208,800	194,617
Sand and gravel	short tons	159,461	183,572
Silver	troy ounces	111,222	100,668
Zinc	pounds	5,411,500	898,309
Unapportioned: chromite, pyrite, limestone, stone (misc.)			932,232
Total value			$2,488,653

Sierra County

Gold	troy ounces	12,765	$446,775
Sand and gravel	short tons	61,986	44,733
Silver	troy ounces	2,380	2,154
Total value			$493,662

Siskiyou County

Chromite	long tons	3,321	$347,925
Gold	troy ounces	99	3,465
Pumice	short tons	2,951	36,430
Silver	troy ounces	15	14
Unapportioned: sand and gravel, stone (misc.)			102,500
Total value			$490,334

Mineral production in California in 1952 by counties—continued

Solano County

Product		Quantity	Value
Natural gas	thousand cubic feet	41,658,049	$10,491,520
Sand and gravel	short tons	182,850	181,875
Stone (misc.)	short tons	326,548	392,737
Total value			$11,066,132

Sonoma County

Mercury	flasks	3,062	$609,644
Sand and gravel	short tons	975,827	817,431
Stone	short tons	145,895	155,072
Other minerals			2,464
Total value			$1,584,611

Stanislaus County

Gold	troy ounces	30	$1,050
Sand and gravel	short tons	349,575	319,033
Silver	troy ounces	2	2
Unapportioned: clay, diatomite			52,140
Total value			$372,225

Sutter County

Sand and gravel	short tons	142,659	$56,229
Unapportioned: clay, natural gas			189,272
Total value			$245,501

Tehama County

Mineral production consisted of chromite and sand and gravel.

Trinity County

Gold	troy ounces	6,794	$237,790
Silver	troy ounces	663	600
Unapportioned: chromite, manganese ore, sand and gravel, stone (misc.)			60,071
Total value			$298,461

Tulare County

Copper	pounds	100	$24
Natural gas	thousand cubic feet	5,482,881	1,159,919
Silver	troy ounces	4	4
Unapportioned: clay, petroleum, sand and gravel, stone (misc.), tungsten ore			817,246
Total value			$1,977,193

Tuolumne County

Gold	troy ounces	133	$4,655
Sand and gravel	short tons	33,697	38,483
Silver	troy ounces	15	14
Unapportioned: lime, limestone, stone (misc.)			775,957
Total value			$819,109

Mineral production in California in 1952 by counties—continued

Ventura County

Product		Quantity	Value
Natural gas	thousand cubic feet	82,575,832	$11,147,910
Natural gasoline	barrels	2,986,000	8,481,000
Liquefied petroleum gas	barrels	1,307,000	2,078,000
Petroleum	barrels	42,011,733	102,255,496
Sand and gravel	short tons	779,827	742,323
Unapportioned: clay, gypsum, limestone, stone (misc.)			430,531
Total value			$125,135,260

Yolo County

Product		Quantity	Value
Natural gas	thousand cubic feet	4,490,650	$760,007
Sand and gravel	short tons	714,291	592,428
Mercury	flasks	2	398
Other minerals			5,582
Total value			$1,358,415

Yuba County

Product		Quantity	Value
Unapportioned: gold, platinum, sand and gravel, silver			$1,982,862

MINERAL COMMODITIES, 1952 AND 1953

Andalusite. A small quantity of andalusite was shipped during 1952 and 1953 from a stockpile at the mine near Mocalno in the White Mountains of Inyo County.

Antimony. A small tonnage of antimony was mined in both 1952 and 1953 but no shipments were made. The Antimony Queen mine in the Agua Caliente District of Kern County produced in 1952. The 1953 production was made from the Big Oscar mine in the Green Horn Mountain District of Kern County.

Asbestos. The asbestos reported shipped in 1953 came from single properties in Placer, Siskiyou, and Tuolumne Counties. The material coming from Placer County was tremolite and was shipped for use in acid filters; that from Siskiyou and Tuolumne Counties was short fiber chrysotile and was shipped to Los Angeles for the local market.

In 1952 no production was reported from California properties. Chrysotile deposits were explored in Shasta, Trinity, Nevada, Calaveras, Lake, San Benito and Inyo Counties, but no commercial production resulted.

Barite. During 1953 shipments of barite were made from single properties in Plumas and San Bernardino Counties. In addition, another property in San Bernardino made some production but did not ship ore. The barite shipped from San Bernardino County was a by-product from the mining of rare earth minerals near Mountain Pass. The 1952 barite output in California came from the Almanor mine in Plumas County. In the last several years the quantity of barite shipped from California sources has gradually been declining.

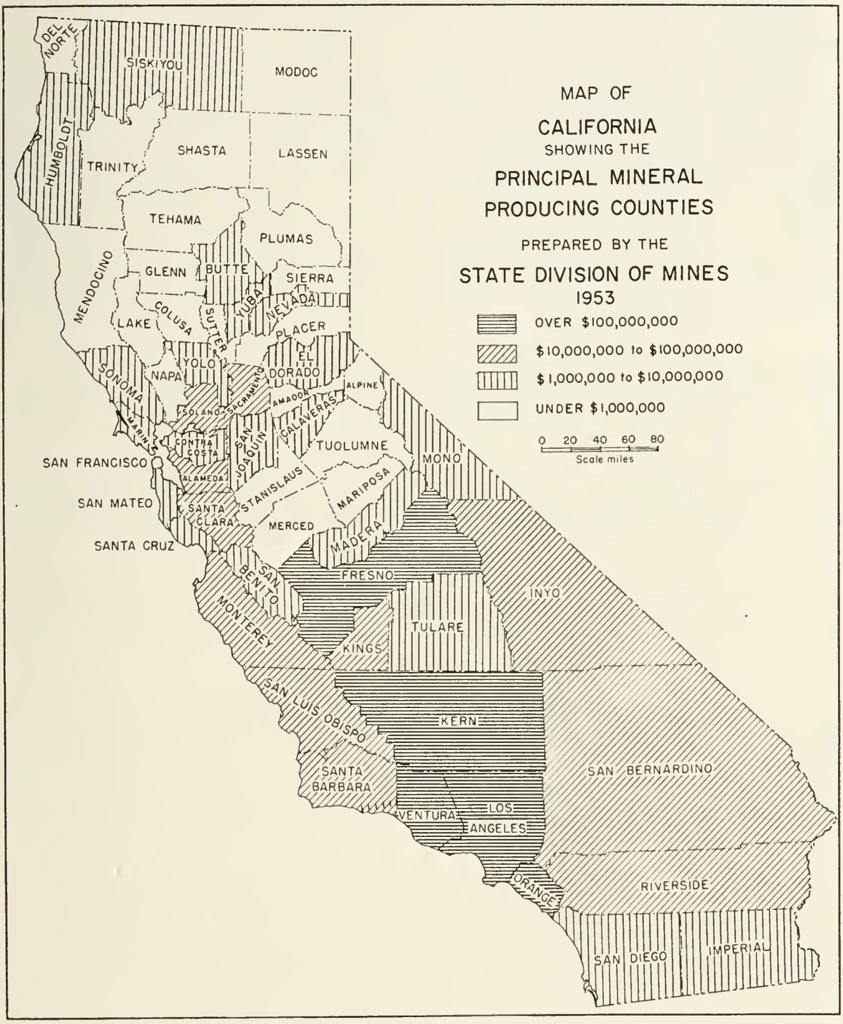
MAP OF
CALIFORNIA
SHOWING THE
PRINCIPAL MINERAL
PRODUCING COUNTIES
PREPARED BY THE
STATE DIVISION OF MINES
1953
OVER $100,000,000
$10,000,000 to $100,000,000
$1,000,000 to $10,000,000
UNDER $1,000,000
0 20 40 60 80
Scale miles
DEL NORTE
SISKIYOU
MODOC
HUMBOLDT
TRINITY
SHASTA
LASSEN
TEHAMA
PLUMAS
MENDOCINO
GLENN
BUTTE
SIERRA
NEVADA
YUBA
LAKE
COLUSA
SUTTER
PLACER
SONOMA
NAPA
YOLO
EL DORADO
ALPINE
MARIN
SOLANO
SACRAMENTO
AMADOR
CALAVERAS
SAN FRANCISCO
CONTRA COSTA
SAN JOAQUIN
TUOLUMNE
MONO
ALAMEDA
SAN MATEO
SANTA CLARA
STANISLAUS
MARIPOSA
MERCED
SANTA CRUZ
MADERA
FRESNO
SAN BENITO
INYO
MONTEREY
KINGS
TULARE
SAN LUIS OBISPO
KERN
SAN BERNARDINO
SANTA BARBARA
VENTURA
LOS ANGELES
ORANGE
RIVERSIDE
SAN DIEGO
IMPERIAL

FIGURE 2.

Borates. California is the only producer of boron minerals in the United States. The principal production is from Kern County. The output of boron minerals produced in California increased from 583,828 short tons worth $14,105,000 in 1952 to 715,228 short tons worth $17,668,000 in 1953. The 1953 production was considerably less than that of 1951 when 862,797 short tons worth $20,030,000 were shipped constituting the largest annual output on record. Production came from two properties in Inyo County, two properties in San Bernardino County and one property in Kern County.

Each of the aforementioned counties produced distinctive boron minerals. Colemanite and ulexite were from dry-lake beds in Inyo County, kernite and borax came from Kern County, and borax from dry-lake brines was produced in San Bernardino County.

About half the total production is consumed in the glass and ceramic industries.

Bromine. The bromine produced in California during 1952 and 1953 came from single properties in Alameda and San Bernardino Counties. The production from Alameda County was recovered from salt water bitterns purchased from the salt works on San Francisco Bay. The San Bernardino County production came from Searles Lake brines.

Most of the bromine was used in the manufacture of ethylene dibromide for anti-knock gasoline. Minor amounts were consumed in the preparation of photographic emulsions, chemical reagents, and pharmaceuticals.

Cadmium. A small quantity of cadmium was recovered by out-of-state zinc smelters treating California ores. The zinc ores were mined in the Coso District, Inyo County; the Ingot District, Shasta County; and along the West Belt of Calaveras County.

Calcium Chloride. Three properties on Bristol Lake, in San Bernardino County, accounted for the California output of calcium chloride during 1952 and 1953. The output and value for 1953 was the largest on record.

The principal use of calcium chloride is in the stabilization of dirt roads and in dust control. Other uses are for strengthening concrete and for ''freeze proofing'' coal, iron ore, and other material shipped in bulk during cold weather.

Carbon Dioxide. Natural carbon dioxide produced in California during 1952 and 1953 came from wells near Niland, Imperial County, and Hopland, Mendocino County. The Imperial County output totaled 150,000 M cubic feet in 1952 and 134,633 M cubic feet in 1953. Most of the carbon dioxide coming from California's natural sources was used in the manufacture of dry ice.

Cement. California is the second ranking state in the production of cement. The cement production and shipments in California during 1953 were the largest of any year on record. The 1953 shipments totaled 32,002,317 barrels (376 pounds) and was valued at $90,872,741, compared with 29,786,245 barrels worth $79,457,745 in 1952.

Shipments in 1953 from the five northern California mills totaled 15,166,928 barrels of cement worth $43,930,333 compared with 13,714,018 barrels worth $36,958,815 in 1952. The five northern California mills are located in Calaveras, San Benito, San Mateo, Santa Clara, and Santa Cruz Counties. During 1953, shipments totaling 16,835,389 barrels worth $46,942,408 came from the six southern California mills; three in San Bernardino County and one each in Kern, Los Angeles and Riverside Counties. Comparative 1952 shipments were 16,072,227 barrels worth $42,498,930.

The production of cement in California during 1953 totaled 32,145,447 barrels (376 pounds) of which 15,125,072 barrels came from the northern California mills and 17,020,375 barrels from the southern California mills. The 1952 production totaled 29,584,905 barrels, of which northern California mills accounted for 13,676,126 barrels and southern California mills 15,908,779 barrels.

Crude materials consumed by California cement mills, 1953.

	Northern California mills	Southern California mills	State total
Limestone oyster shells, cement rocks	4,292,678	4,640,151	8,932,829
Aluminous* and siliceous rocks	732,830	422,173	1,155,003
Iron ore, pyrite cinder and mill scale	22,867	61,286	84,153
Gypsum	102,566	115,255	217,821
Miscellaneous**	803	1,036	1,839

* Includes alluvium, clay, clay shale, tufa, mica schist, quartz, sandstone, diorite, quartzite, and altered volcanic rocks.
** Includes fluorspar, air-entraining compounds, calcium chloride, grinding aids and tuff pozzolan.

Crude materials consumed by California cement mills during 1953 totaled 10,391,645 short tons, and their distribution is shown in the accompanying table.

The estimated capacity of California cement mills as of January 1, 1954 was 37,420,000 barrels, compared with 36,020,000 barrels for January 1, 1953. Capacity of the northern California mills in 1954 was 15,900,000 barrels and southern California mills was 21,520,000 barrels.

Chromite. During 1953 chromite production in California reached its highest point since 1944. California was the principal producer in the United States during 1952, supplying 69 percent of the total production.

The chromite mined and shipped from California during 1953 totaled 1,030,422 long ton units or an equivalent of 22,898 long tons of 45 percent Cr_2O_3 ore valued at $2,078,461, as compared with 13,137 long tons of chrome ore recalculated to 13,820 long tons of 45 percent Cr_2O_3 worth $1,269,129 for 1952. Most of the ore mined in 1952 and 1953 was shipped to the U. S. General Services Administration stockpile at Grants Pass, Oregon.

The 1953 chromite output was made by 86 operators on 97 properties in 15 counties, compared with 46 operators on 41 properties in 12

Chromite shipments by counties, 1952 and 1953.

County	1952		1953	
	Long tons	Value	Long tons	Value
Butte	1,229	$36,349	*	*
Del Norte	4,625	484,637	3,273	$310,012
El Dorado	*	*	619	55,426
Placer	*	*	35	3,697
San Luis Obispo	*	*	8,877	733,574
Shasta	*	*	66	4,876
Siskiyou	3,321	347,925	4,595	467,224
Tehama	*	*	977	97,946
Trinity	*	*	213	22,251
Other counties	[a]4,645	400,218	[b]4,243	383,455
Totals	13,820	$1,269,129	22,898	$2,078,461

* Included with other counties.
[a] Includes El Dorado, Fresno, Monterey, Placer, San Luis Obispo, Santa Barbara, Shasta, Tehama, and Trinity Counties.
[b] Includes Fresno, Glenn, Lake, Napa, Santa Barbara, and Santa Clara Counties.

counties during 1952. San Luis Obispo County was the principal producer in 1953, and Del Norte County in 1952. The accompanying table records the 1952 and 1953 chromite shipments by counties.

Clay. The crude clay produced in California during 1953 came from 84 clay pits in 25 counties. Production totaled 1,534,239 short tons worth $4,057,074, exclusive of 589,166 short tons worth $608,027 which was used in the manufacture of portland cement. The 1952 output of raw clay was 1,886,649 short tons worth $3,993,052 exclusive of clay used in the manufacture of cement; this production came from 79 clay pits in 25 counties. The accompanying table records the distribution by counties of crude clays produced in California during 1952 and 1953.

Crude clay produced in 1952 and 1953, by counties.

County	1952		1953	
	Short tons	Value	Short tons	Value
Alameda	13,810	$12,650	11,690	$12,590
Amador	165,979	547,319	117,021	324,243
Contra Costa	61,888	82,720	*	*
Kern	122,406	831,901	68,324	599,704
Los Angeles	566,557	615,462	420,922	428,671
Orange	21,871	76,795	47,313	178,981
Placer	121,560	252,020	*	*
Riverside	195,692	594,288	255,934	1,063,611
Sacramento	*	*	19,493	33,043
San Bernardino	23,616	247,492	41,930	353,850
Santa Clara	55,511	45,797	17,245	14,751
Other counties	[a]537,759	686,608	[b]534,367	1,047,630
Totals	1,886,649	$3,993,052	1,534,239	$4,057,074

* Included with 'Other Counties'

[a] Includes Calaveras, Fresno, Humboldt, Inyo, Marin, Mono, Sacramento, San Benito, San Diego, San Joaquin, Santa Barbara, Stanislaus, Sutter, Tulare, and Ventura Counties.

[b] Includes Calaveras, Contra Costa, Fresno, Humboldt, Inyo, Marin, Mono, Placer, San Benito, San Diego, San Joaquin, Santa Barbara, Solano, Stanislaus, Sutter, Tulare, and Ventura Counties.

Kaolin produced and used during 1953 in California totaled 29,296 short tons valued at $410,428, as compared with 21,589 short tons worth $256,906 in 1952. Fire clay including stoneware clay produced in California during 1953 totaled 452,740 short tons valued at $1,606,100 as compared with 562,135 short tons worth $1,717,964 in 1952. Miscellaneous clay, including common brick clay, shale, filler clay, oil-well drilling mud and others, produced in California during 1953 totaled 1,143,088 short tons worth $2,015,940 as compared with 1,220,932 short tons worth $1,123,073 in 1952. Other clays produced were bentonite, fullers earth and ball clay.

Coal. The coal (lignite) mined in Amador County, California, during 1953 totaled 2,390 short tons, as compared with 2,998 short tons in 1952.

In 1946 work was started on a plant to extract montan wax from the lignite deposits at Ione, Amador County. This plant began operating in 1947 and the company has been mining a small tonnage of coal annually. The montan wax from this plant is used in such products as shoe polish, carbon paper, and as a substitute for carnauba wax. A van dyke brown pigment is also made from coal at this plant and is used in paints and polishes. The plant residue is used as a soil conditioner.

Copper. Copper production in California during 1953 was the lowest in 19 years. The recoverable copper produced in California during 1953 totaled 764,000 pounds valued at $219,268, as compared with 1,600,000 pounds worth $387,200 in 1952. Most of the California copper is produced as a by-product of other metals. In Inyo County copper concentrates were made from tungsten ores at the Pine Creek mill. The copper from Shasta and Calaveras Counties was recovered from copper-zinc ores. The copper output by counties for 1952 and 1953 is shown in the accompanying table.

Copper output by counties, 1952 and 1953.

County	1952		1953	
	Pounds	Value	Pounds	Value
Calaveras	528,500	$127,897	56,000	$16,072
El Dorado			158,000	45,346
Inyo	319,000	77,198	302,100	86,703
Kern	800	194		
Madera	37,000	8,954	102,800	29,504
Nevada	800	194	9,300	2,669
Riverside	2,200	532	600	172
San Bernardino	77,900	18,852	78,400	22,501
Shasta	633,700	153,355	*	*
Tulare	100	24		
Sierra and Shasta			56,800	16,301
Totals	1,600,000	$387,200	764,000	$219,268

* Combined with Sierra County in 1953.

Diatomite. California is the principal source of diatomite in the United States. Santa Barbara County is usually the leading producer. Most of the diatomite mined and shipped in California during 1952 and 1953 came from the operations of two large companies in Santa Barbara and Los Angeles Counties. In 1952 diatomite production was reported from Stanislaus County and a small production was made also in Inyo County. In 1953 a property in Napa County reported production for the first time.

In 1952 production fell considerably below that of the previous year, owing to a strike at the Lompoc property in Santa Barbara County. Full scale production was resumed in 1953.

Feldspar. The feldspar reported mined and shipped in 1952 and 1953 came from single properties in Monterey and San Bernardino Counties. Most of the feldspar produced in California was used by glass and ceramic industries, but some was used in the enamel industry and in soaps and cleansers.

Fluorspar. During 1952 and 1953 the Holmestake Mining Co. was converting its gold mill near Winterhaven, Imperial County, for the recovery of fluorspar from local ores.

Gem Stones. Since most of the transactions in gemstones involve collectors, mineral dealers and itinerant prospectors who made only

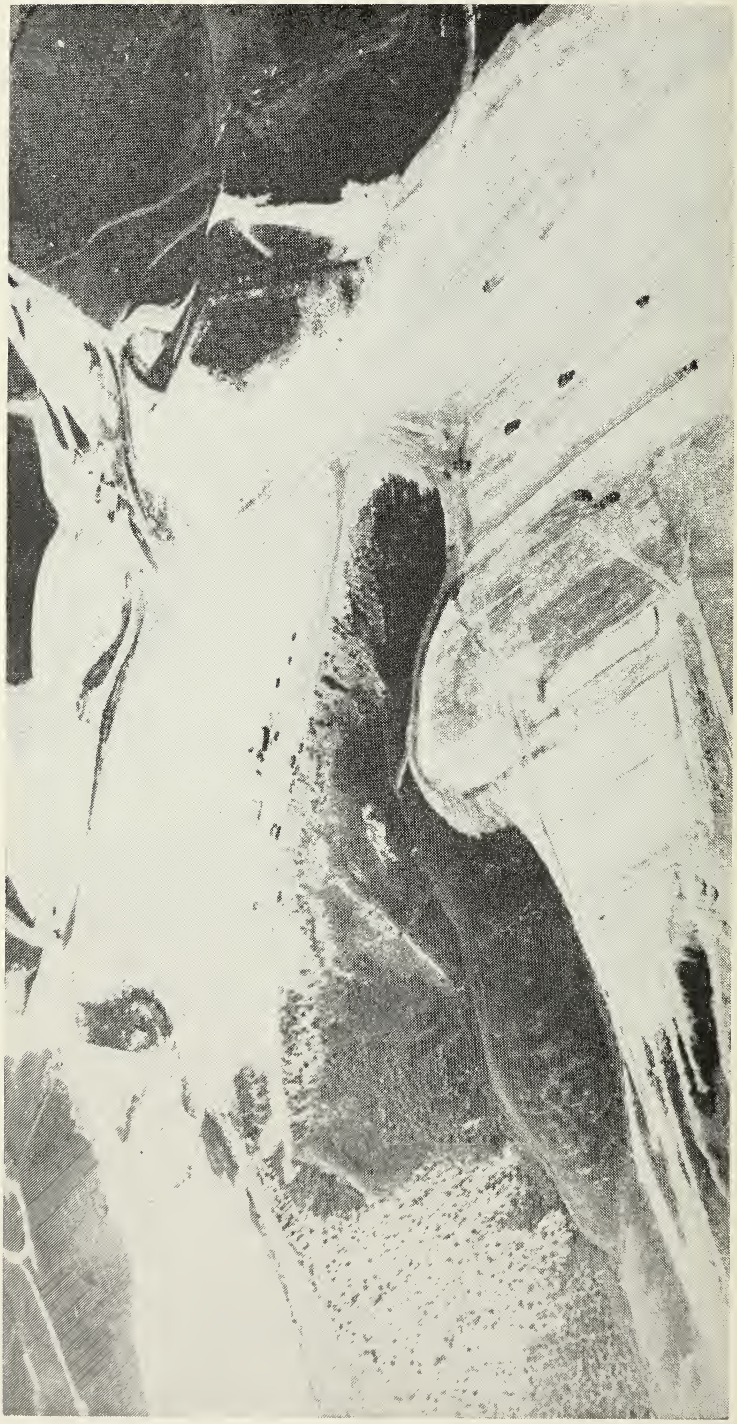

FIGURE 3. Dicalite Division (Great Lakes Carbon Corporation) quarry in the north syncline about 7 miles southeast of Lompoc. Careful scrutiny of the photograph reveals indivual beds of diatomaceous shale which follow the syncline trough-shaped fold. These beds are not all of the same composition but are quarried selectively by carryall. The operator is now leveling off the deposit so that a complete circuit of the syncline along selected beds may eventually be made. *Photo by courtesy of the company.*

intermittent production, it is difficult to obtain accurate production figures for this commodity. During 1952 and 1953 agate was produced in the Mojave Desert region; tourmaline in San Diego County; idocrase in Siskiyou County; jade in Mendocino, Monterey and San Benito Counties; benitoite in San Benito County; and jasper in Santa Clara County.

Gold. The gold produced in California during 1953 totaled 234,591 fine ounces worth $8,210,685, compared with 258,176 fine ounces worth $9,036,160 in 1952. Of the 1953 output 111,245 fine ounces came from the lode mines and 123,346 fine ounces from the placers, mainly dredges; compared with 115,833 fine ounces from lode mines and 142,343 fine ounces from placers in 1952. The 1953 output came from 150 lode mines and 123 placer mines in 31 counties and that of 1952 came from 141 lode mines and 108 placer mines.

The following information giving an outline of the gold activities during 1953, was taken from a report by R. B. Maurer and R. E. Wallace.*

Gold, historically the principal metal mined in California, which was relegated to number three position behind tungsten and iron ore in 1952, did not rally in 1953 largely because of waning placer mining and the almost static condition of lode mines. Placer mines yielded about 51 percent of the state total of gold, and lode mines about 49 percent. Two events that brightened the generally gloomy outlook among gold producers were the opening of operations by Siskon Corporation at its Dillon Creek, Siskiyou County, Siskon open-pit gold mine and cyanide mill in September 1953 and the addition of a new deep-dredging boat to the Yuba unit, Yuba County, fleet of dredges in August 1953. The "big-four" among California gold producers, Natomas Company, with dredges working in the American River district, Sacramento County, Yuba Consolidated Gold Fields, with dredges working in the Yuba River district, Yuba County, Empire Star Mines, Ltd., and Idaho Maryland Mines Corporation, the last two working gold ore in the Grass Valley-Nevada City district, Nevada County, furnished about 77 percent of California's 1953 gold. Other producers that contributed noteworthy quantities of gold to the total state output were: *Amador County*—Central Eureka Mining Company, Old Eureka mine (gold ore), Mother Lode district; Lorentz and Swingle, Lorentz group, Cosumnes River district (dragline dredging). *Calaveras County*—Mountain Gold Dredging Company, McCarty and Gillam properties (dragline dredging), West Belt district. *El Dorado County*—Hazel Creek Mining Corporation, Hazel Creek mine, East Belt district (gold ore). *Kern County*—Burton Brothers Incorporated, Tropico and Cactus mines and custom milling (gold ore), Mojave district; King Solomon Lease, Yellow Aster mine (gold ore), Randsburg district. *Los Angeles County*—Robert Riggs, San Gabriel Valley placers, San Gabriel district. *Madera County*—Howell Brothers, Werly Ranch, Chowchilla River district; D. J. Yearout, Heiskell property, Fresno River district (suction dredging). *Mariposa County*—Seaview Lumber Company, Horseshoe mine, East Belt district (gold ore); Adobe Mining Company, Waltz property (suction dredging), West

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* Maurer, R. B., and Wallace, R. E., Gold, silver, copper, lead, and zinc production in California in 1953; U. S. Bureau of Mines, Annual Area Report C-10.

Production of gold by counties, 1952 and 1953.

Counties	1952						1953					
	Mines producing[1]		Fine ounces		Totals		Mines producing[1]		Fine ounces		Totals	
	Lode	Placer	Lode	Placer	Fine ounces	Value	Lode	Placer	Lode	Placer	Fine ounces	Value
Amador	3	4	6,690	211	6,901	$241,535	5	6	3,028	226	3,254	$113,890
Butte	1	7	3	8,572	8,575	300,125	2	6	5	192	197	6,895
Calaveras	4	4	871	1,006	1,877	65,695	5	8	195	741	936	32,760
El Dorado	5	5	5,853	52	5,905	206,675	9	7	7,356	75	7,431	260,085
Fresno		4		277	277	9,695	*	*	*	*	*	*
Humboldt								[2]		10	10	350
Imperial	4		412		412	14,420	*				*	*
Inyo	26		2,764		2,764	96,740	20		970		970	33,950
Kern	12	3	9,531	259	9,790	342,650	10	5	2,937	72	3,009	105,315
Los Angeles	*	*	*	*	*	*	1	1	3	155	158	5,530
Madera	4	6	86	139	225	7,875	2	5	[3]	98	98	3,430
Mariposa	12	[2]	631	35	666	23,310	11	1	430	261	691	24,185
Modoc	3		75		75	2,625						
Mono	*		*		*	*	3		176		176	6,160
Monterey							1		4		4	140
Nevada	9	17	74,842	1,077	75,919	2,657,165	8	11	69,942	337	70,279	2,459,765
Placer	1	10	13	540	553	19,355	1	16	*	525	525	18,375
Plumas	1	4	1	107	108	3,780	4	3	49	157	206	7,210
Riverside	7		33		33	1,155	6		14		14	490
Sacramento	1	7	21	73,333	73,354	2,567,390	2	9	54	65,136	65,190	2,281,650
San Bernardino	19	*	668	*	668	23,380	16	2	675	15	690	24,150
San Diego								[2]		14	14	490
San Mateo		[2]		3	3	105		[2]		1	1	35
Shasta	8	[2]	669	71	740	25,900	5	2	98	62	160	5,600
Sierra	8	8	12,534	231	12,765	446,775	12	12	21,161	425	21,586	755,510
Siskiyou	3	13	4	95	99	3,465	7	7	3,738	129	3,867	135,345
Stanislaus		[2]		30	30	1,050						
Trinity	1	8	25	6,769	6,794	237,790	3	14	35	5,662	5,697	199,395
Tulare	1						1					
Tuolumne	4	1	102	31	133	4,655	12	3	72	17	89	3,115
Other counties[3]	4	7	5	49,505	49,510	1,732,850	4	5	303	49,036	49,339	1,726,865
Totals	141	108	115,833	142,343	258,176	$9,036,160	150	123	111,245	123,346	234,591	$8,210,685

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* Included with other counties.

[1] Excludes itinerant prospectors, "snipers," high-graders, and others who gave no evidence of legal right to the property.

[2] From properties not classed as mines.

[3] 'Other counties' in 1952 included lode gold from Los Angeles, Mono, and Yuba Counties and placers of Merced and San Bernardino Counties; in 1953 includes placer gold from Del Norte, Fresno, Merced, and Yuba Counties and lode gold from Imperial, Madera, Modoc, and Placer Counties.

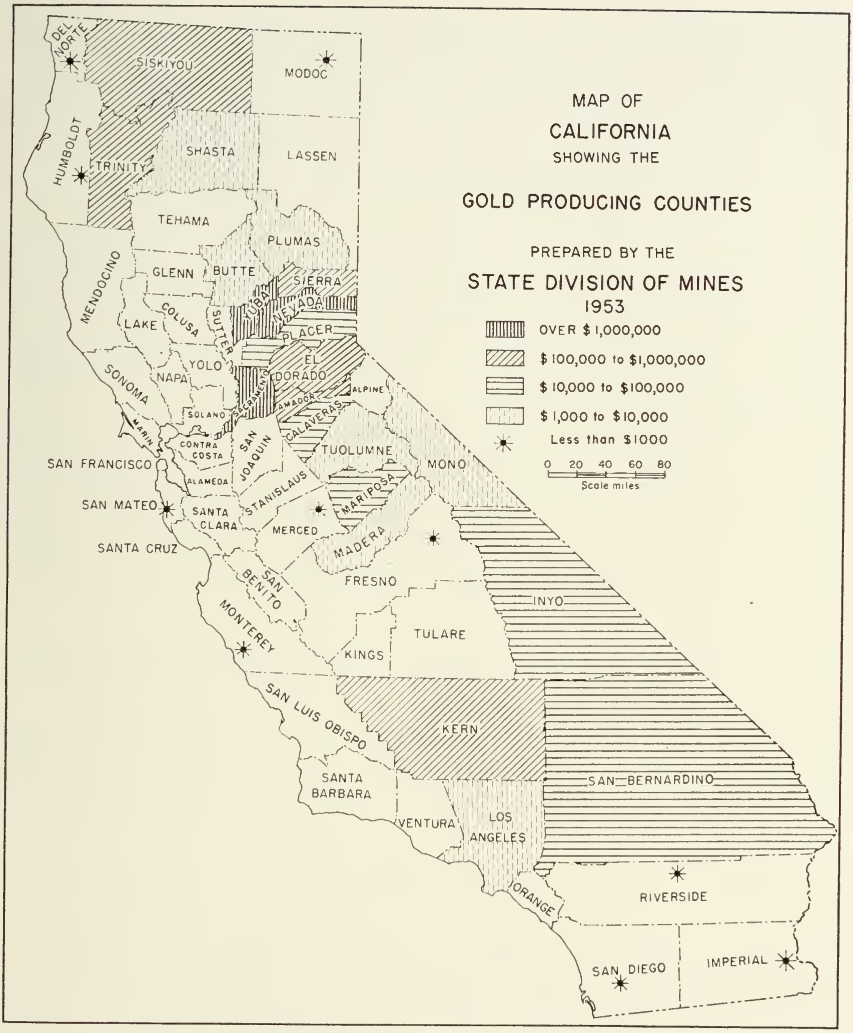
MAP OF
CALIFORNIA
SHOWING THE
GOLD PRODUCING COUNTIES
PREPARED BY THE
STATE DIVISION OF MINES
1953
OVER $1,000,000
$100,000 to $1,000,000
$10,000 to $100,000
$1,000 to $10,000
Less than $1000
0 20 40 60 80
Scale miles
DEL NORTE
SISKIYOU
MODOC
HUMBOLDT
TRINITY
SHASTA
LASSEN
TEHAMA
PLUMAS
MENDOCINO
GLENN
BUTTE
SIERRA
YUBA
NEVADA
COLUSA
SUTTER
LAKE
PLACER
YOLO
EL DORADO
SONOMA
NAPA
SACRAMENTO
ALPINE
AMADOR
SOLANO
CALAVERAS
MARIN
CONTRA COSTA
SAN JOAQUIN
TUOLUMNE
SAN FRANCISCO
MONO
ALAMEDA
STANISLAUS
MARIPOSA
SAN MATEO
SANTA CLARA
MERCED
MADERA
SANTA CRUZ
SAN BENITO
FRESNO
INYO
MONTEREY
TULARE
KINGS
SAN LUIS OBISPO
KERN
SANTA BARBARA
SAN BERNARDINO
VENTURA
LOS ANGELES
ORANGE
RIVERSIDE
SAN DIEGO
IMPERIAL

FIGURE 4.

Belt district. *Mono County*—Valley View Mines Company, Chemung & Sarita mines, Masonic district (gold ore). *Nevada County*—Willow Valley Mines, Incorporated, Willow Valley group (gold ore), Grass Valley-Nevada City district; Crescent Pacific Mining Company, Middle Yuba placer and Red Ledge Mines, Red Ledge mine (gold ore), Washington (North Bloomfield) district. *Placer County*—W. B. Pendleton, American Hill mine, Last Chance district; W. E. Wilson, Paragon mine, Foresthill district, (hydraulic). *San Bernardino County*—Dick Bright, Telegraph mine, Solo district (gold ore). *Shasta County*—Whiskey Hill mine, Shasta district (gold ore). *Sierra County*—The Original Sixteen to One Mine, Incorporated, Original Sixteen to One mine; Dickey Exploration Company, Oriental mine, Yellow Jacket Consolidated Gold Mine, Red Star mine, H. E. Hawn, and Kate Hardy mine—all treating gold ore in the Alleghany district; Best Mines Company, Brush Creek mine (gold ore), Downieville district. *Siskiyou County*—Siskon Corporation, Siskon mine (gold ore), Klamath River district. *Trinity County*—Fairview Placers (the only bucket-line dredge operated in California other than those in the two major fleets), Bennett Mining Company and Browns Creek Placer (hydraulicking), all in the Trinity River district. *Yuba County*—Empire Star Mines, Limited, Browns Valley group, Browns Valley district (gold ore).

Gypsum. The value of the gypsum output in California during 1953 was the largest on record, but the quantity of production was exceeded by that in 1952. The crude gypsum produced in California during 1953 totaled 1,199,489 short tons worth $2,855,983 and came from six properties in Kern County; two properties each in Kings and San Luis Obispo Counties; and one property each in Fresno, Imperial, Merced, Riverside and Ventura Counties.

In 1952 production of 1,236,430 short tons worth $2,721,134 was made from five properties in Kern County, two properties each in Kings and San Luis Obispo Counties, and one property each in Fresno, Imperial, Merced, Riverside, and Ventura Counties. In addition, a considerable quantity of synthetic gypsum was produced each year as a byproduct in the reduction of magnesia from sea water at a plant in Alameda County. This byproduct gypsum was not included in the state totals.

California agriculturalists purchased 597,520 short tons of gypsum as a soil conditioner in 1953, compared with 708,593 short tons in 1952.

Iodine. California is the only state in the nation in which iodine is produced. Two companies recovered iodine during 1952 and 1953, from oil well waters at the Dominguez, Long Beach, Inglewood, and Seal Beach oil fields. The first three fields are in Los Angeles County. The Seal Beach oil field is partly in Los Angeles County and partly in Orange County.

Iron Ore. The iron ore produced in California during 1953 was the largest on record in both quantity and value. Production totaled 1,697,652 long tons and came from two properties in San Bernardino County and one property each in Riverside and Shasta Counties. In 1952 production totaled 1,463,239 long tons and originated at one property in Riverside County and three properties in San Bernardino County. Shipments of usable iron ore from California deposits averaged 56.2 percent iron in 1952.

The principal production of iron ore in California comes from the Captive Eagle Mountain mine in Riverside County which ships to the blast furnaces of the Kaiser Steel Company at Fontana in San Bernardino County. The output of the Cave Canyon mine in San Bernardino County was used in the manufacture of ''low-heat'' cement.

Lead. The lead produced in California during 1953 totaled 17,328,000 pounds worth $2,269,968 as compared with 22,398,000 pounds worth $3,606,078 in 1952. The accompanying table records the 1952 and 1953 lead output in California by counties.

In 1952 the principal producers of lead were Darwin group in the Coso district and the Shoshone group in the Resting Springs district.

All these mines are in Inyo County and are operated by the Anaconda Copper Mining Company. The Afterthought mine in the Ingot district, Shasta County, operated by the Coronado Copper and Zinc Company also produced in 1952. In 1953 the only appreciable producer of lead was the Darwin group in Inyo County.

Lead output in California by counties, 1952 and 1953.

County	1952		1953	
	Pounds	Value	Pounds	Value
Calaveras	93,800	$15,102	4,100	$537
El Dorado	28,700	4,621	38,000	4,978
Imperial	300	48		
Inyo	20,918,700	3,367,911	17,262,500	2,261,388
Kern	200	32	4,200	550
Mariposa	4,300	692		
Mono	11,000	1,771	3,300	432
Riverside	12,200	1,964	2,100	275
San Bernardino	120,000	19,320	11,200	1,467
Shasta	1,208,800	194,617		
Siskiyou			1,100	144
Trinity			1,500	197
Totals	22,398,000	$3,606,078	17,328,000	$2,269,968

Lime. Lime production in California registered an all-time high in quantity and value during 1953. The lime burned in California during 1953 totaled 301,422 short tons worth $4,653,303 as compared with 238,957 short tons worth $3,752,738 in 1952. The lime produced in 1953 and 1952 came from two properties each in El Dorado and San Bernardino Counties and one property each in Monterey and Tuolumne Counties.

The principal consumers of lime were the chemical, the refractories, the building and the agricultural industries.

Limestone (see stone).

Lithium. The brines of Searles Lake, San Bernardino County, California, are the chief source of the state's lithium. The crude material coming from these brines in 1952 and 1953 was a sodium lithium phosphate carrying 20.5 percent Li_2O.

Magnesite. The magnesite shipped in 1952 and 1953 came from the Western mine on Red Mountain, Santa Clara County. The material shipped during 1952 was used in the manufacture of refractories and that in 1953 went into the manufacture of epsom salts.

Magnesium Compounds (from sea water and bitterns). The magnesia (magnesium oxide) produced in California during 1953 and 1952 came from three plants, one each in Alameda, Monterey, and San Mateo Counties. Magnesium chloride was recovered from sea water or from salt works bitterns at a plant in San Diego County. The 1953 output totaled 55,886 short tons worth $3,843,483, as compared with 50,204 short tons worth $3,529,362 in 1952.

The plant in San Mateo County produced magnesium oxide, magnesium carbonate, and magnesium hydroxide U.S.P. or technical grades which were used chiefly in pharmaceutical preparations. The material from Alameda and Monterey Counties was used in refractories, oxychloride cements, rayon, insulation, epsom salts, and for other purposes.

Insulation manufacturers in Alameda and San Mateo Counties purchased magnesium oxide from the primary producers and converted it into magnesium carbonate for pipe coverings.

Magnesium Metal. A small production of magnesium metal was made during 1952 and 1953 by the Kaiser Magnesium Company at the U. S. Government-owned plant in Manteca, San Joaquin County. In the process, calcined dolomite was mixed with ferrosilicon, retorted and the resulting metallic vapors were condensed and refined. Operations were terminated in July 1953.

Manganese Ore. Manganese ore mining was stimulated by the U. S. Government purchase program and production in California during 1953 reached the highest point since 1944. During 1953 manganese ore was produced at 55 properties in 13 counties, namely: Humboldt, Imperial, Inyo, Lake, Mendocino, Plumas, Riverside, San Benito, San Bernardino, San Joaquin, San Luis Obispo, Sonoma, and Trinity. Production totaled 8,750 short tons of manganese ore containing over 35 percent Mn worth $443,743, and 8,274 short tons of manganiferous ore containing 5 to 35 percent Mn worth $317,645. All the manganiferous ore and about half of the manganese ore went to the Government stockpiles, chiefly to Wenden, Arizona. The remainder of the manganese ore was used in the manufacture of dry batteries or was shipped to steel mills.

The 1952 output came from nine properties in Imperial, Inyo, Plumas, Riverside, San Joaquin, and Trinity Counties and consisted of 8,081 short tons of manganese ore and 105 short tons of manganiferous ore.

Mercury (Quicksilver). California is the principal mercury producing state and contributed 58 percent of the national total in 1952 and 65 percent in 1953.

The 1953 mercury output came from 33 properties distributed through Del Norte, Fresno, Lake, Merced, Napa, San Benito, San Luis Obispo, Santa Clara, Sonoma, Stanislaus, and Trinity Counties. Production totaled 9,290 flasks of 76 pounds worth $1,793,249 compared with an output of 7,241 flasks worth $1,441,683 in 1952. The latter production was made from 25 properties in Contra Costa, Del Norte, Fresno, Lake, Napa, San Benito, San Luis Obispo, Santa Clara, Sonoma, and Yolo Counties.

The New Idria mine in San Benito County was the largest producer in the United States in both 1952 and 1953. The second largest producing mine in California was the Mt. Jackson in Sonoma County, followed by the Abbott mine in Lake County.

Mineral Pigments. Mineral pigments manufactured in California during 1952 and 1953 came from plants in Alameda and Amador Counties. The one in Alameda County produced iron-oxide pigments and the one in Amador County produced a van dyke brown made from coal (lignite).

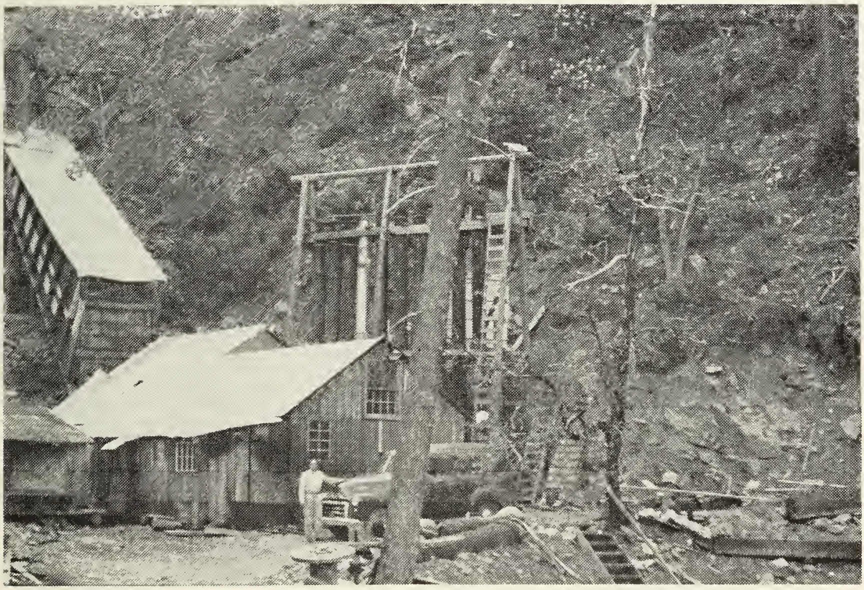

FIGURE 5. Ore bin, chute, and treatment plant at Webb quicksilver mine, Patricks Creek, Del Norte County.

Mineral Water. Water from many springs and artesian wells, bottled and in part artificially carbonated, is classed as mineral water. Health and pleasure resorts are located at many hot springs in California. The water at some of the hot springs is not suitable for drinking, but is utilized for bathing. Counties from which mineral waters are bottled and sold are: Butte, Calaveras, Contra Costa, Lake, Los Angeles, Marin, Napa, Orange, Riverside, San Benito, San Bernardino, San Diego, San Francisco, San Luis Obispo, Santa Barbara, Shasta, Siskiyou, Sonoma, and Tehama. No canvass of mineral water producers is made by the U. S. Bureau of Mines.

Molybdenum. Molybdenum concentrates were produced in California as a by-product of tungsten recovery. The 1952 and 1953 output came from the Pine Creek mine of the U. S. Vanadium Corporation near Bishop, Inyo County.

Natural Gas. The value of natural gas coming from California wells in 1953 was the largest of any year on record, although the quantity of production was below the all-time high recorded in 1948. The 1953 output of natural gas utilized was 531,346,000 M cubic feet worth $104,675,000 and came from wells in 23 counties, as compared with 517,450,000 M cubic feet worth $86,414 000 from 21 counties in 1952.

Natural Gas Liquids. All-time highs in quantity and value of production of natural gas gasoline and liquefied petroleum gases were reported in California during 1953. Both commodities, of which California is the second largest producer, were recovered at plants near the oil fields. During 1953 21,675,000 barrels of natural gas gasoline and cycle products valued at $85,691,000 were recovered in California compared with 20,738,000 barrels worth $64,954,000 in 1952.

Natural gas used by counties, 1952 and 1953.

County	1952		1953	
	M cubic feet	Value	M cubic feet	Value
Butte	2,020,520	$366,383	3,401,365	$693,334
Fresno	40,785,112	6,523,674	42,079,823	8,928,917
Kern	71,505,994	10,445,036	94,344,606	18,222,198
Kings	27,770,240	4,336,215	28,745,543	6,036,564
Los Angeles	101,956,302	13,855,874	93,302,408	16,309,874
Madera	3,043,308	459,872	2,830,648	600,635
Orange	32,712,511	4,943,164	32,702,054	5,559,349
Sacramento	64,340,787	15,555,970	61,504,310	15,745,103
San Joaquin	6,166,095	1,490,805	4,396,924	984,735
San Luis Obispo	2,456,493	462,804	1,287,649	193,347
Santa Barbara	26,146,129	3,476,809	23,155,454	3,589,095
Solano	41,658,049	10,491,520	40,712,320	10,442,303
Tulare	5,482,881	1,159,919	4,871,897	1,065,502
Ventura	82,575,832	11,147,910	89,379,665	14,658,265
Yolo	4,490,650	760,007	3,533,100	624,228
Other counties	[a]4,339,097	938,038	[b]5,098,234	1,021,551
Totals	517,450,000	$86,414,000	531,346,000	$104,675,000

[a] Includes natural gas produced in Alameda, Contra Costa, Glenn, Humboldt, Monterey, and Sutter Counties.

[b] Includes natural gas produced in Contra Costa, Glenn, Humboldt, Monterey, San Benito, San Bernardino, Sonoma, and Sutter Counties.

Natural gasoline produced, 1952 and 1953.

County	1952		1953	
	Barrels	Value	Barrels	Value
Fresno	1,512,000	$5,068,000	1,387,000	$5,940,000
Kern	5,323,000	17,105,000	5,659,000	22,261,000
Kings and San Luis Obispo	975,000	3,251,000	796,000	3,159,000
Los Angeles	6,284,000	19,527,000	6,377,000	25,485,000
Orange	2,839,000	8,996,000	3,090,000	12,818,000
Santa Barbara	819,000	2,517,000	1,003,000	3,858,000
Ventura	2,986,000	8,481,000	3,363,000	12,170,000
Totals	20,738,000	$64,945,000	21,675,000	$85,691,000

Liquefied petroleum gases produced by counties, 1952 and 1953.

County	1952		1953	
	Barrels	Value	Barrels	Value
Fresno	1,481,000	$3,074,000	1,293,000	$3,284,000
Kern	3,475,000	6,619,000	2,850,000	7,213,000
Kings and San Luis Obispo	963,000	1,877,000	1,098,000	2,512,000
Los Angeles	1,097,000	1,495,000	1,084,000	2,175,000
Orange	386,000	581,000	1,182,000	2,604,000
Santa Barbara	667,000	976,000	525,000	1,025,000
Ventura	1,307,000	2,078,000	1,434,000	3,148,000
Totals	9,376,000	$16,700,000	9,466,000	$21,961,000

The liquefied petroleum gases produced in California during 1953 totaled 9,466,000 barrels worth $21,961,000, compared with 9,376,000 barrels worth $16,700,000 in 1952.

Petroleum production in California, 1952 and 1953.

County	1952		1953	
	Barrels	Value	Barrels	Value
Fresno	38,527,006	$95,257,648	35,721,937	$97,874,113
Kern	89,971,259	190,503,861	93,579,987	217,068,703
Kings	3,529,472	9,523.517	2,991,428	9,333,236
Los Angeles	98,395,105	226,237,767	97.341,785	254,678,447
Monterey	8,287,391	9,197,962	11,320,483	13,707,134
Orange	38,321,332	86,971,305	37,532,320	93,136,528
San Luis Obispo	3,362,536	8,560,935	3,263,470	10,014,937
Santa Barbara	36,995,788	73,264,758	35,374,509	81,167,227
Ventura	42,015,824	102,253,960	47,751,662	131,567,967
Other counties	[a]44,287	98,286	[b]55,421	131,708
Totals	*359,450,000	$801,870,000	364,933,000	$908,680,000

[a] Includes San Benito, San Bernardino, Santa Clara, Sonoma, and Tulare Counties.
[b] Includes Humboldt, San Benito, San Bernardino, Santa Clara, Sonoma, and Tulare Counties.
* Revised figures.

Peat. The peat mined and shipped in California during 1952 and 1953 came from properties in Contra Costa, Modoc, and Orange Counties. Production in 1953 totaled 9,196 dry short tons worth $73,897 compared with 6,942 dry short tons worth $76,707 in 1952.

Perlite. The crude perlite produced in California during 1953 came from properties in Inyo, Napa, and San Bernardino Counties and totaled 15,282 short tons worth $112,790 compared with 18,368 short tons worth $128,637 from properties in the same counties in 1952.

Expanded perlite totaling 35,342 short tons worth $1,601,988 was sold from nine plants in Los Angeles County and one plant each in Contra Costa, Fresno, Marin, Napa, San Bernardino, and San Diego Counties during 1953. These figures compare with 28,419 short tons worth $1,202,603 sold from six plants in Los Angeles County, two plants each in Napa and San Bernardino Counties, and one plant each in Contra Costa, Marin, and San Diego Counties during 1952.

Petroleum. California is the second largest producer of petroleum in the nation. The 1953 output of crude oil was the largest on record in both quantity and value. During 1953 California oil wells produced 364,933,000 barrels of petroleum worth $908,680,000, compared with 359,450,000 barrels worth $801,570,000 in 1952.

Platinum. California is the leading state in the production of platinum group metals. The crude platinum produced in California during 1953 came from dredges in Sacramento and Yuba Counties, while the crude platinum produced in 1952 came from properties in Butte, Sacramento, San Mateo, and Yuba Counties. The 1952 production was chiefly from dredges although a token production came from a beach placer in San Mateo County.

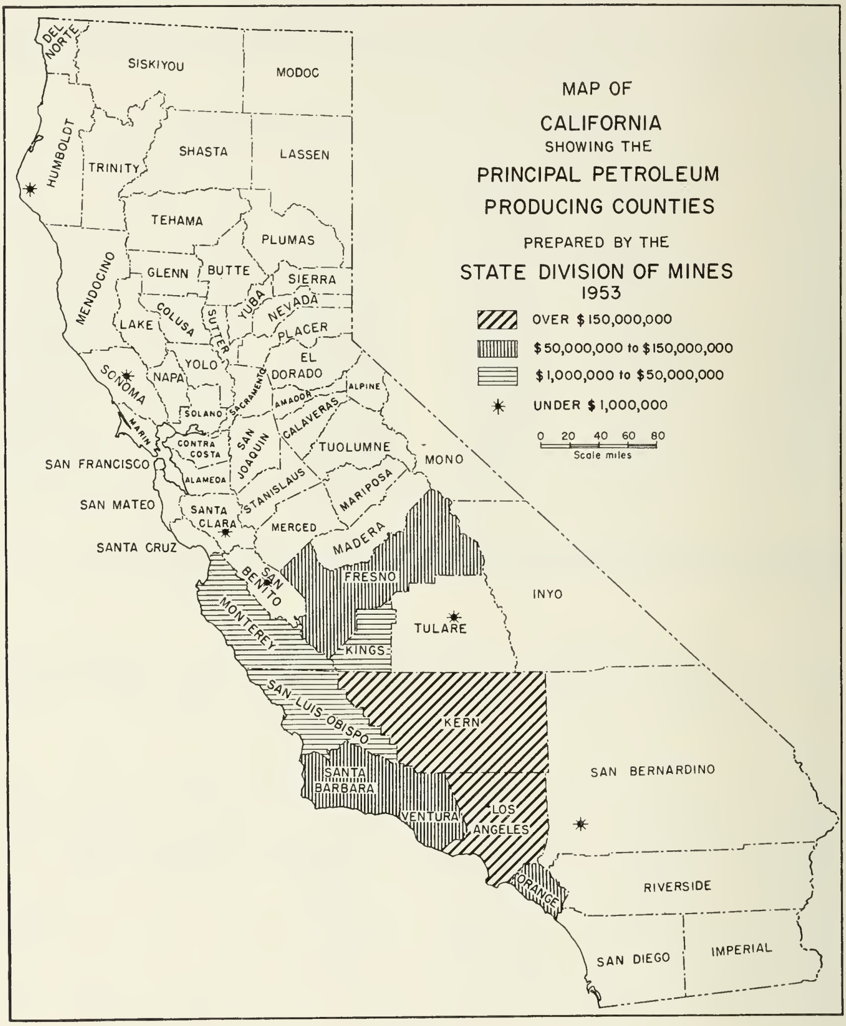
MAP OF
CALIFORNIA
SHOWING THE
PRINCIPAL PETROLEUM
PRODUCING COUNTIES
PREPARED BY THE
STATE DIVISION OF MINES
1953
▨ OVER $150,000,000
▥ $50,000,000 to $150,000,000
▤ $1,000,000 to $50,000,000
✱ UNDER $1,000,000
0 20 40 60 80
Scale miles
DEL NORTE
SISKIYOU
MODOC
HUMBOLDT
TRINITY
SHASTA
LASSEN
TEHAMA
PLUMAS
MENDOCINO
GLENN
BUTTE
SIERRA
NEVADA
YUBA
SUTTER
COLUSA
LAKE
PLACER
EL DORADO
YOLO
NAPA
SONOMA
SOLANO
SACRAMENTO
AMADOR
ALPINE
CALAVERAS
MARIN
CONTRA COSTA
SAN JOAQUIN
TUOLUMNE
MONO
SAN FRANCISCO
ALAMEDA
STANISLAUS
MARIPOSA
SAN MATEO
SANTA CLARA
MERCED
SANTA CRUZ
MADERA
SAN BENITO
FRESNO
INYO
MONTEREY
TULARE
KINGS
SAN LUIS OBISPO
KERN
SAN BERNARDINO
SANTA BARBARA
VENTURA
LOS ANGELES
ORANGE
RIVERSIDE
SAN DIEGO
IMPERIAL

FIGURE 6.

Potash. California is the second ranking state in the production of potassium salts. Potassium salts were produced in California during 1952 and 1953 from the brines of Searles Lake, San Bernardino County, by the America Potash and Chemical Company.

Pumice and Pumicite. California was the second ranking state in the production of pumice and pumicite. The pumice and pumicite produced in California in 1953 totaled 80,814 short tons valued at $451,499 and came from properties in Amador, Calaveras, Imperial, Inyo, Kern, Madera, Modoc, Mono, San Bernardino, and Siskiyou Counties. In 1952 production was 129,780 short tons worth $793,716 and came from properties in Calaveras, Imperial, Inyo, Kern, Madera, Modoc, Mono, Napa, San Bernardino, and Siskiyou Counties. The material from Amador, Calaveras, Imperial, Modoc, Mono, Napa, and Sis-

Production of sand and gravel by counties, 1952 and 1953.

County	1952		1953	
	Short tons	Value	Short tons	Value
Alameda	5,758,892	$6,023,956	5,598,583	$6,029,133
Alpine	25,607	22,550	*	*
Amador	*	*	35,762	10,765
Butte	425,874	424,079	340,758	478,224
Colusa	388,211	151,181	201,627	111,341
Contra Costa	179,824	126,501	84,242	55,771
Del Norte	108,288	95,483	144,193	146,601
El Dorado	*	*	93,437	74,312
Fresno	2,916,540	1,962,310	927,764	698,451
Glenn	342,604	171,308	298,774	196,147
Humboldt	757,521	428,362	791,955	755,299
Imperial	325,777	104,987	508,066	370,049
Inyo	71,283	36,926	126,579	88,569
Kern	860,789	722,589	555,714	628,928
Lake	137,193	93,422	111,323	71,543
Lassen	31,587	33,325	146,887	84,422
Los Angeles	15,204,792	11,330,512	19,819,526	14,969,723
Madera	100,275	17,200	*	*
Marin	31,102	25,633	*	*
Mariposa	101,974	144,687	27,903	50,028
Mendocino	165,674	220,294	189,956	264,076
Merced	473,463	487,387	950,504	877,347
Modoc	180,736	44,283	340,693	110,676
Mono	24,156	13,894	*	*
Monterey	815,752	1,695,815	1,114,261	2,786,154
Napa	76,561	128,604	5,703	3,058
Nevada	*	*	61,327	30,324
Orange	2,294,243	1,846,451	3,003,406	2,629,786
Placer	215,150	60,990	1,029,943	532,043
Plumas	113,062	51,590	*	*
Riverside	1,247,036	1,583,994	803,469	1,168,394
Sacramento	5,667,454	2,017,177	6,551,061	4,710,063
San Benito	48,081	33,000	*	*
San Bernardino	1,474,462	1,268,155	2,168,881	2,173,938
San Diego	2,653,414	3,302,871	3,100,522	4,287,389
San Joaquin	2,043,938	1,823,755	1,664,436	1,552,198
San Luis Obispo	237,795	199,410	264,415	188,620
San Mateo	329,667	360,669	*	*
Santa Barbara	408,836	559,919	371,285	522,922
Santa Clara	781,050	595,212	1,038,679	729,125
Santa Cruz	660,646	641,174	648,371	620,038
Shasta	159,461	183,572	259,259	260,355
Sierra	61,986	44,733	*	*
Siskiyou	*	*	186,411	242,809
Solano	182,850	181,875	*	*
Sonoma	975,827	817,431	*	*
Stanislaus	349,575	319,033	539,607	475,118
Sutter	142,659	56,229	*	*
Tehama	*	*	71,138	75,623
Trinity	*	*	35,747	43,656
Tuolumne	33,697	38,483	*	*
Ventura	779,827	742,323	910,238	1,146,794
Yolo	714,291	592,428	1,203,039	1,022,846
Other counties	907,142	[a]967,557	[b]2,127,905	2,006,237
Not distributed by counties	1,064,636	839,806	*	147,790
Totals	53,051,260	$43,633,125	58,453,349	$53,426,685

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* Included with "Not distributed by counties."

[a] Includes: Amador, Calaveras, El Dorado, Kings, Nevada, Siskiyou, Tehama, Trinity, Tulare and Yuba Counties in 1952.

[b] Includes: Alpine, Calaveras, Kings, Madera, Marin, Mono, Plumas, San Benito, San Mateo, Solano, Sonoma, Sutter, Tulare, Tuolumne and Yuba Counties in 1953.

kiyou Counties and a portion of that from Inyo, Madera, and San Bernardino Counties was pumice; while that from Kern County and a portion of that from Inyo, Madera, and San Bernardino Counties was pumicite or volcanic ash.

Pyrite. Pyrite produced in California during 1952 and 1953 came from the Hornet mine at Matheson, Shasta County. This mine has been the chief source of the state's pyrite output for many years.

Quicksilver (see Mercury).

Rare Earth Minerals. Rare earth minerals were produced commercially for the first time in California during 1952 from a property near Mountain Pass in San Bernardino County by Molybdenum Corporation of America. The mineral found there is bastnasite, a fluocarbonate of cerium and lanthanum. This operation continued through 1953.

Salt. California is one of the principal salt-producing states. Most of the production is made by the solar evaporation of sea water. The value of the 1953 salt crop in California was largest of any year on record, although the quantity produced was less than that of 1951 and 1952. In 1953 a production of 1,123,365 short tons of crude salt worth $6,263,059 was reported. Production came from four properties in Alameda County, three properties in San Bernardino County, and one property each in Kern, Monterey, Orange, and San Diego Counties. These figures compare with 1,148,693 short tons of crude salt worth $4,880,392 produced from the same properties in 1952.

Sand and Gravel. California leads all states in the production of sand and gravel. The California output of sand and gravel in 1953 was the largest in both quantity and value of any year on record.

Since a high percentage of sand and gravel is used in building and related construction projects, the largest production was made near large metropolitan centers. The combined value of production from Los Angeles and Alameda Counties constituted 40 percent of the state total.

Production totaled 58,453,349 short tons worth $53,426,685, compared with 53,051,260 short tons worth $43,633,125 in 1952.

Silica. The silica, both quartz and sand, produced in California during 1953 came from two properties in San Bernardino County and one property each in Kern, Mariposa, and Monterey Counties, while the silica produced during 1952 came from single properties each in Mariposa, Monterey, and San Bernardino Counties. The material from San Bernardino, Kern, and Mariposa Counties was quartz and was used in the manufacture of refractories and ferrosilicon; the silica sand from Monterey County was used in the ceramics, the building, and the glass industries.

Silver. Silver in California is a by-product of gold and base metal ore mining. The silver output in California during 1953 totaled 1,036,372 fine ounces worth $937,969, as compared with 1,099,658 fine ounces worth $995,246 in 1952. During 1953 the lode mines accounted for 1,029,147 fine ounces of silver and the placer mines only 7,225 fine ounces. In 1952 the lode mines produced 1,091,184 fine ounces of silver and the placers 8,474 fine ounces.

Silver production by counties, 1952 and 1953.

County	1952		1953	
	Fine ounces	Value	Fine ounces	Value
Amador	1,497	$1,355	708	$641
Butte	797	721	22	20
Calaveras	39,037	35,330	1,694	1,533
El Dorado	2,101	1,901	2,934	2,655
Fresno	44	40	*	*
Imperial	182	165	*	*
Inyo	856,523	775,197	987,468	893,708
Kern	45,393	41,083	3,858	3,492
Los Angeles	*	*	29	26
Madera	364	329	26	24
Mariposa	368	333	129	117
Mono	*	*	2,336	2,114
Modoc	70	63	*	*
Monterey	------	------	3	3
Nevada	22,519	20,381	18,080	16,363
Placer	59	53	64	58
Plumas	7	6	31	28
Riverside	427	386	64	58
Sacramento	3,127	2,830	2,786	2,521
San Bernardino	7,014	6,348	3,395	3,073
San Diego	------	------	15	14
San Mateo	1	1	------	------
Shasta	111,229	100,668	22	20
Sierra	2,380	2,154	5,321	4,816
Siskiyou	15	14	2,144	1,940
Stanislaus	2	2	------	------
Trinity	663	600	585	529
Tulare	4	4	137	124
Undistributed	[a]5,835	5,282	[b]4,521	4,092
Totals	1,099,658	$995,246	1,036,372	$937,969

* Included with 'Undistributed.'

[a] Includes silver mined in 1952 from Los Angeles, Merced, Mono, Tuolumne, and Yuba Counties.

[b] Includes silver mined in 1953 from Del Norte, Fresno, Imperial, Merced, Modoc, and Yuba Counties.

The following was taken from Maurer * in preliminary report of the U. S. Bureau of Mines, on gold, silver, copper, lead, and zinc production in California in 1953:

> Byproduct silver from the Anaconda Copper Company Darwin group of mines, lead-zinc and lead ores, accounted for a preponderant percentage of the State silver in 1953. The State total silver was bolstered by consistent output of the metal recovered with gold from California gold mines and in copper concentrate recovered from tungsten ore at the United States Vanadium Corp., Pine Creek mill, Bishop district, Inyo County. Occasional shippers of lead-zinc and lead ores to smelters contributed some silver to the State total.

Slate. Slate was mined and shipped in California during 1952 and 1953 from two quarries in El Dorado County. The material was used as flagstone, roofing granules, and the slate flour as a filler.

Sodium Salts. California is the largest producer of natural sodium carbonates and sulfates. These salines are extracted from the brines of the desert dry lakes in the southeastern part of the state.

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* Maurer, R. B., Gold, silver, lead and zinc production in California in 1953: U. S. Bur. Mines, Annual Area Rept. C-10, 1953

Production of miscellaneous stone by counties, 1952 and 1953.

County	1952		1953	
	Short tons	Value	Short tons	Value
Alameda	1,166,824	$1,129,231	1,179,307	$1,181,338
Butte	*	*	248,023	210,359
Contra Costa	*	*	945,603	1,236,269
Del Norte	13,000	5,200	18,900	20,250
El Dorado	*	*	26,387	39,460
Fresno	333,327	398,407	500,414	403,893
Humboldt	*	*	26,476	72,798
Imperial	*	*	27,518	35,481
Los Angeles	3,871,159	3,352,808	3,090,102	2,820,052
Monterey	*	*	57,293	62,125
Orange	253,845	235,081	*	*
San Bernardino	269,627	231,349	333,478	330,361
San Diego	262,442	396,777	340,169	562,359
Santa Clara	*	*	928,073	547,570
Siskiyou	*	*	33,325	37,955
Solano	326,548	392,737	*	*
Sonoma	145,895	155,072	*	*
Tehama	----------	----------	9,441	17,133
Trinity	18,564	31,113	----------	----------
Tuolumne	7,813	2,693	18,045	10,346
Other counties	[a]5,530,950	6,034,139	[b]4,943,503	5,908,796
Not segregated by counties	602,210	900,056	45,558	48,730
Totals	12 802,204	$13,264,663	12,771,615	$13,545,275

* Included with 'Other counties.'

[a] Includes Amador, Butte, Contra Costa, El Dorado, Humboldt, Imperial, Kern, Marin, Monterey, Napa, Placer, Plumas, Riverside, Sacramento, San Benito, San Joaquin, San Mateo, Santa Clara, Santa Cruz, Shasta, Siskiyou, Tulare, Ventura, and Yolo Counties.

[b] Includes Lassen, Madera, Marin, Mariposa, Merced, Mono, Napa, Orange, Placer, Plumas, Riverside, Sacramento, San Benito, San Joaquin, San Mateo, Santa Barbara, Santa Cruz, Shasta, Sonoma, Solano, Tulare, Ventura, and Yolo Counties.

The sodium carbonate produced in California from natural sources during 1953 came from two properties on Searles Lake, San Bernardino County, and one property on Owens Lake, Inyo County. The value of the 1953 output was the largest on record but the quantity was exceeded by that of 1951. During 1952 two properties in each of the above mentioned counties reported production of soda ash and trona.

The salt cake produced in California during 1952 and 1953 came from a single property on Searles Lake, San Bernardino County. The value of the 1953 output was the largest so far reported.

Stone. California is one of the large stone producing states. Most of its production is made in the crushed stone classification and the products find use chiefly in concrete aggregate and road surfacing. Some of the rock types contributing to this production are: granite, limestone, dolomite, chert, sandstone and basalt.

Granite (Dimension Stone). The granite quarried in California during 1953 for monumental and building stone usage totaled 37,451 cubic feet (3,226 short tons) worth $235,025. Production came from four quarries in San Diego County and one quarry each in Fresno, Madera, Placer, and San Bernardino Counties.

These figures compare with 45,937 cubic feet worth $365,437 in 1952, coming from six quarries in San Diego County, and one quarry each in Fresno, Lassen, Placer, and San Bernardino Counties.

Limestone, Marble, and Dolomite. The limestone, marble, and dolomite quarried in California during 1953 totaled 1,747,077 short tons worth $4,920,551, not including that used in the manufacture of cement. Production came from properties in El Dorado, Kern, Monterey, Riverside, San Benito, San Bernardino, San Luis Obispo, San Mateo, Santa Clara, Santa Cruz, Tuolumne, and Ventura Counties. In addition to the above figures, the cement industry in California produced and used during 1953 a total of 8,932,829 short tons of limestone, oyster shells, and cement rock.

The limestone and dolomite output for 1953 was an increase in both quantity and value over that of 1952 which totaled 1,628,462 short tons worth $4,160,209. The 1952 production came from properties in El Dorado, Kings, Monterey, Riverside, San Benito, San Bernardino, San Diego, San Luis Obispo, San Mateo, Santa Barbara, Santa Clara, Santa Cruz, Shasta, Tuolumne, and Ventura Counties. Not included in the above figures for 1952 were 8,358,055 short tons of limestone, oyster shells, and cement rock.

Miscellaneous Crushed. During 1953 a total of 12,771,615 short tons of crushed stone, rubble, fill rock and flagstone worth $13,545,275 was quarried in California, as compared with 12,802,204 short tons worth $13,264,663 in 1952.

Strontium Minerals. A small amount of celestite was produced in Imperial County during 1953 and 1952.

Sulfur. The production of sulfur ore in California during 1953 totaled 153,203 long tons and was far in excess of any previous annual production. A small production was made in 1952.

During the summer of 1952 contract stripping of overburden at the Leviathan sulfur mine in Alpine County was begun for the Anaconda Copper Mining Company. Here, native sulfur occurs disseminated through a gray, fine-grained to glassy volcanic rock. The sulfur is predominantly a bright canary yellow color, although some of the ore is black.

Open pit mining of the ore body in 15-foot benches was begun by the company in 1953. The mining and loading are done by the company and the ore is delivered to a transportation contractor who hauls it to a sulfuric acid plant at Yerington, Nevada, 55 miles away. The sulfur ore is crushed and roasted for the manufacture of sulfuric acid, which is used to leach copper from a company-owned low grade copper deposit.

Small tonnages of sulfur ore were shipped each year from deposits in Inyo County for agricultural use. By-product sulfur was recovered at California oil refineries.

Talc, Soapstone, and Pyrophyllite. California is one of the principal producers of talc. Talc (including soapstone and pyrophyllite) production in California during 1953 totaled 126,442 short tons valued at $1,132,700, compared with 120,574 short tons valued at $2,868,255 in 1952.

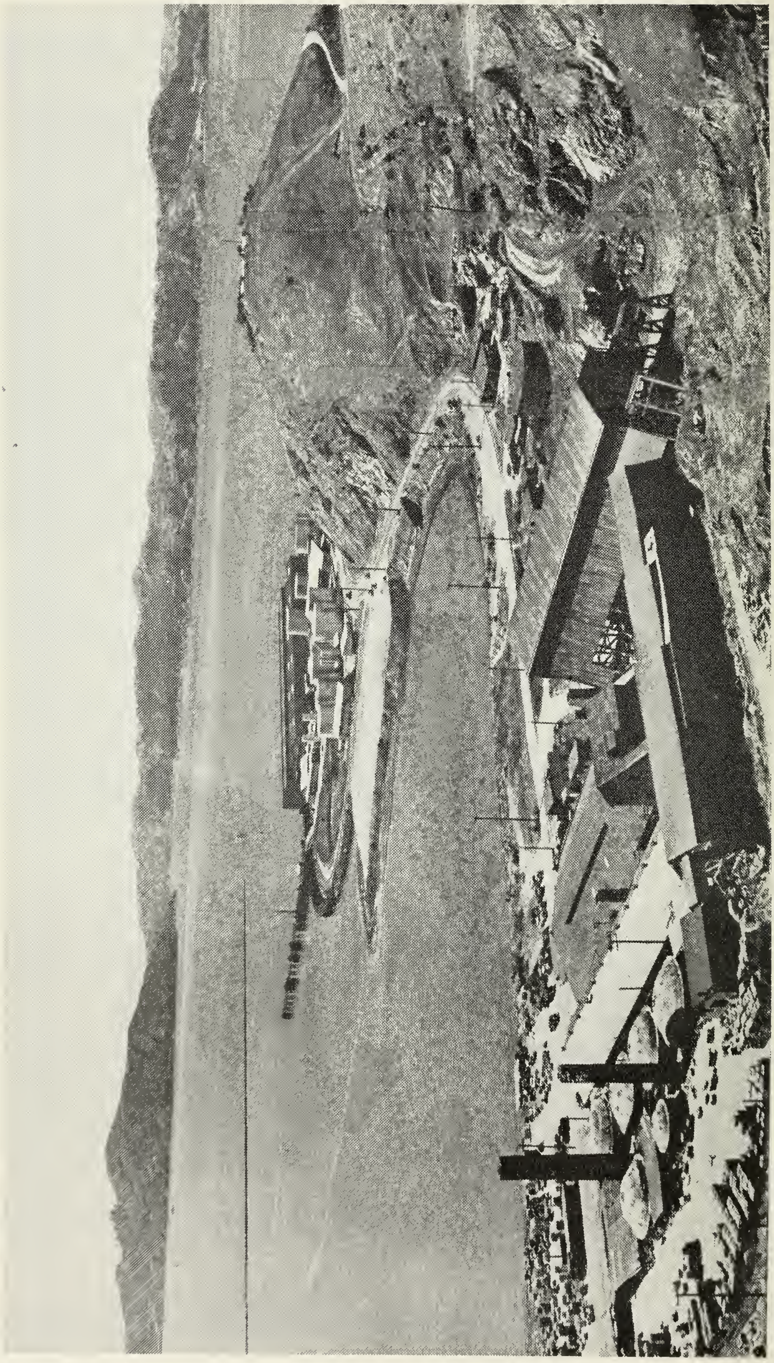

FIGURE 7. United Materials and Richmond Brick Company, Point Richmond, Contra Costa County. *Photo by Mort D. Turner.*

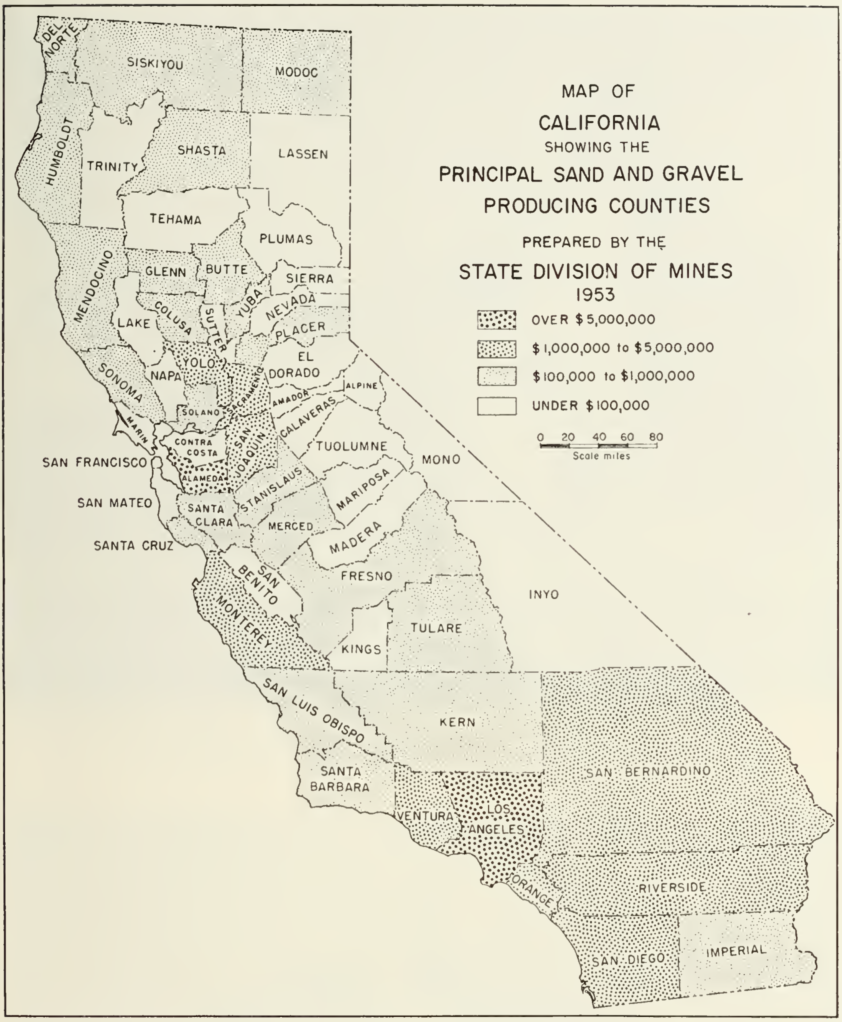
MAP OF
CALIFORNIA
SHOWING THE
PRINCIPAL SAND AND GRAVEL
PRODUCING COUNTIES
PREPARED BY THE
STATE DIVISION OF MINES
1953
OVER $5,000,000
$1,000,000 to $5,000,000
$100,000 to $1,000,000
UNDER $100,000
0 20 40 60 80
Scale miles
DEL NORTE
SISKIYOU
MODOC
HUMBOLDT
TRINITY
SHASTA
LASSEN
TEHAMA
PLUMAS
MENDOCINO
GLENN
BUTTE
SIERRA
LAKE
COLUSA
SUTTER
YUBA
NEVADA
PLACER
SONOMA
NAPA
YOLO
EL DORADO
ALPINE
MARIN
SOLANO
SACRAMENTO
AMADOR
CALAVERAS
SAN FRANCISCO
CONTRA COSTA
SAN JOAQUIN
TUOLUMNE
MONO
ALAMEDA
STANISLAUS
MARIPOSA
SAN MATEO
SANTA CLARA
MERCED
MADERA
SANTA CRUZ
SAN BENITO
FRESNO
INYO
MONTEREY
KINGS
TULARE
SAN LUIS OBISPO
KERN
SANTA BARBARA
SAN BERNARDINO
VENTURA
LOS ANGELES
ORANGE
RIVERSIDE
SAN DIEGO
IMPERIAL

FIGURE 8.

Most of the crude talc was mined in San Bernardino and Inyo Counties. Soapstone was mined in El Dorado and Los Angeles Counties. Pyrophyllite was mined in Mono and Inyo Counties.

Ground talc is used in the ceramics, paint, insecticide, rubber, roofing, paper and other industries.

Titanium. A small amount of ilmenite was produced during 1952 from the sands at Hermosa Beach, Los Angeles County. The product was used as roofing granules.

Tungsten. California is the leading state in the shipment of tungsten concentrates and the second largest producer of tungsten ore and concentrates. Since California mills also receive for treatment ore pro-

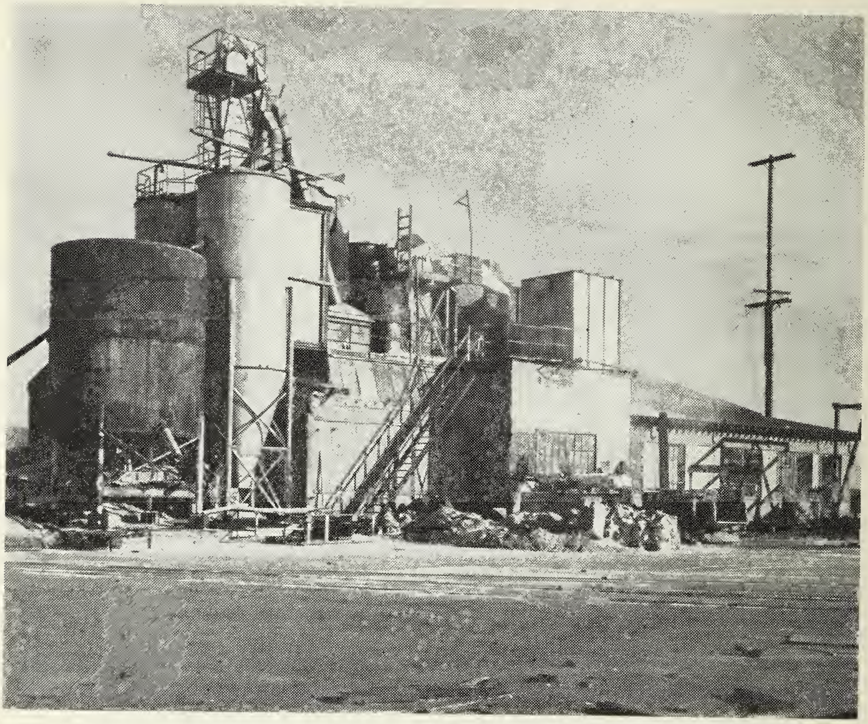

FIGURE 9. Expanding plant of American Perlite Corporation, Richmond, Contra Costa County. *Photo by C. W. Chesterman.*

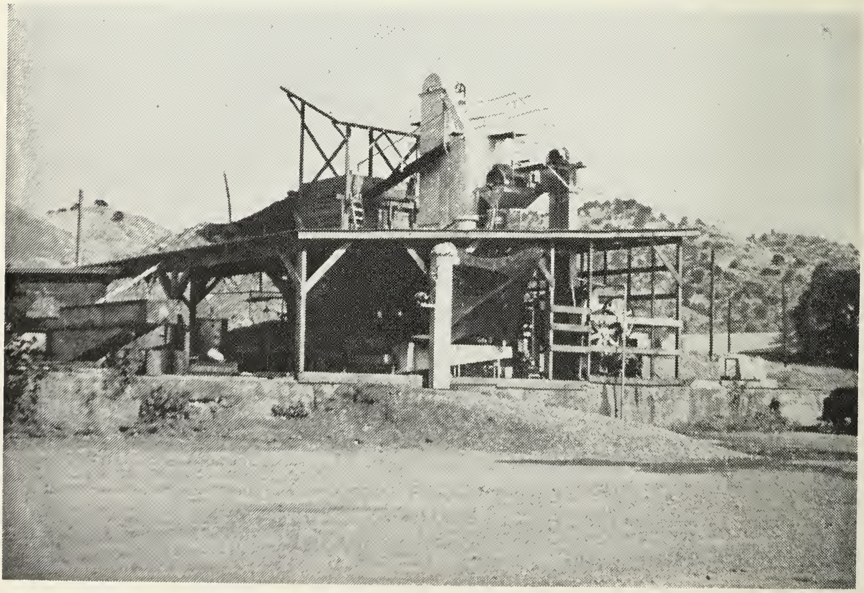

FIGURE 10. Tungsten custom mill northeast of Lemon Cove, Tulare County. Operated by Kaweah Mining and Milling Company. *Photo by J. Grant Goodwin.*

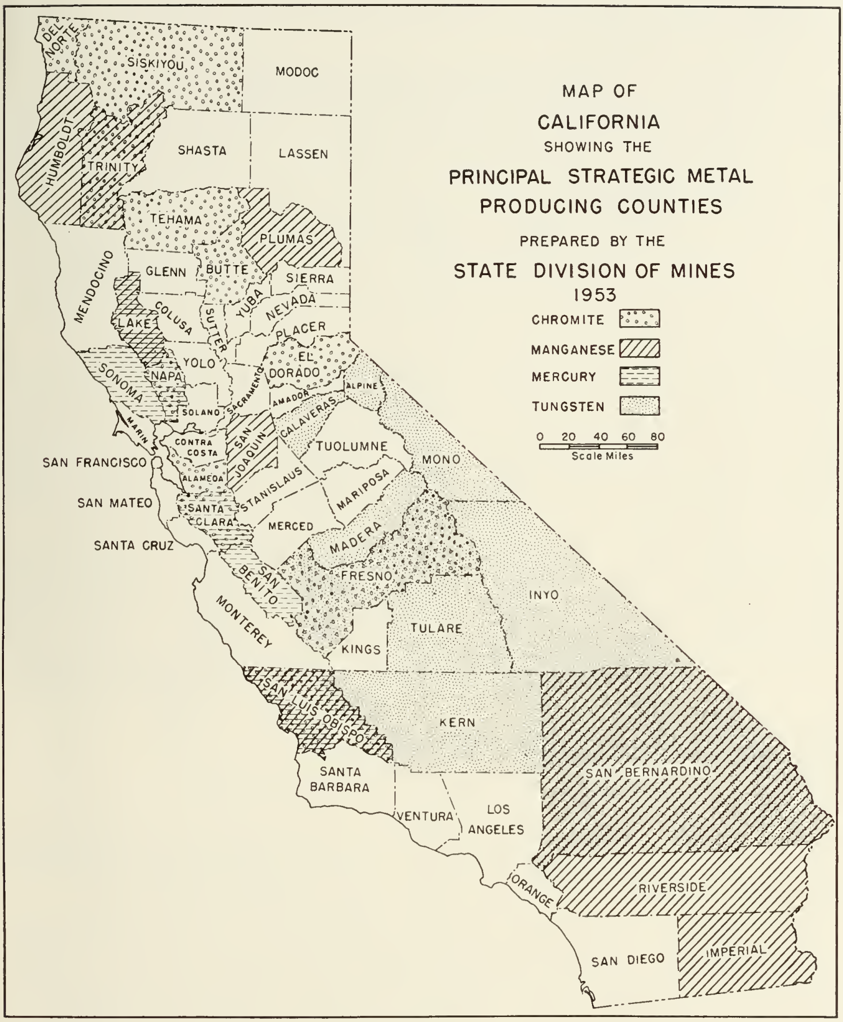
MAP OF
CALIFORNIA
SHOWING THE
PRINCIPAL STRATEGIC METAL
PRODUCING COUNTIES
PREPARED BY THE
STATE DIVISION OF MINES
1953
CHROMITE
MANGANESE
MERCURY
TUNGSTEN
0 20 40 60 80
Scale Miles
DEL NORTE
SISKIYOU
MODOC
HUMBOLDT
TRINITY
SHASTA
LASSEN
TEHAMA
PLUMAS
MENDOCINO
GLENN
BUTTE
SIERRA
COLUSA
SUTTER
YUBA
NEVADA
LAKE
PLACER
YOLO
EL DORADO
SONOMA
NAPA
SACRAMENTO
ALPINE
AMADOR
SOLANO
CALAVERAS
MARIN
SAN JOAQUIN
CONTRA COSTA
TUOLUMNE
SAN FRANCISCO
ALAMEDA
MONO
STANISLAUS
MARIPOSA
SAN MATEO
SANTA CLARA
MERCED
SANTA CRUZ
MADERA
SAN BENITO
FRESNO
INYO
MONTEREY
TULARE
KINGS
SAN LUIS OBISPO
KERN
SANTA BARBARA
SAN BERNARDINO
VENTURA
LOS ANGELES
ORANGE
RIVERSIDE
SAN DIEGO
IMPERIAL

FIGURE 11.

duced in adjoining states, the California total shipments are considerably in excess of total production.

The 1953 production of tungsten concentrates in California totaled 2,123 short tons (60 percent WO_3) valued at \$8,906,808, compared to 2,980 short tons (60 percent WO_3) valued at \$11,360,569 in 1952. The 1952 figures are based on mill production while the 1953 figures are based entirely on mine production.

The following quotation from Maurer presents an outline of tungsten activity during 1953.

> Tungsten concentrate output prospered under the stimulus of government purchases. The U. S. Vanadium Company Pine Creek mine, Bishop district, Inyo County, was the State's largest producer; 85 percent of the state yield was from

the four leading mines. The accompanying table shows the widespread production pattern of the industry.

Tungsten concentrates produced and shipped in 1953 derived from ore mined in California, by counties of origin.

County	Producing mines and prospects	Ore[1]		Concentrates			
		Mined short tons	Treated short tons	Produced pounds	Shipped		
					Pounds	Contained units WO_3	Value[2]
Alpine	2	[3]	[3]	[3]	[3]	[3]	[3]
Calaveras	1	[3]	[3]	[3]	[3]	[3]	[3]
Fresno	5	2,835	2,835	29,141	29,141	999	$62,487
Imperial	2	[3]	[3]	[3]	[3]	[3]	[3]
Inyo	53	217,137	212,692	2,634,948	2,576,028	91,319	5,712,003
Kern	26	1,426	1,276	19,887	19,797	607	37,968
Madera	3	12,682	12,282	222,980	222,980	7,605	475,693
Mariposa	2	700	100	1,000	1,000	32	2,002
Mono	9	68,150	68,145	832,442	810,442	23,179	1,449,846
Riverside	1	300	----------	----------	----------	----------	----------
San Bernardino	23	57,315	57,418	369,551	431,121	13,682	855,809
San Diego	5	1,922	279	4,348	4,348	145	9,071
Tulare	12	21,725	21,281	126,125	126,125	4,002	250,325
Tuolumne	1	[4]	96	940	940	28	1,751
Undistributed	--	2,808	2,808	23,781	23,781	797	49,853
Total	145	387,000	379,000	4,265,143	4,245,703	142,395	$8,906,808

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[1] Partly estimated.
[2] Value of $62.55 per unit based on average of GSA purchases.
[3] Included with undistributed to avoid disclosure of individual output.
[4] Dump ore.
* Maurer, R. B., the mineral industries of California in 1953, Area report C-12, 1954.

Wollastonite. A small production of wollastonite, a calcium metasilicate, was reported from Riverside County during 1952. Wollastonite has many applications in the ceramic and chemical industries.

Zinc. Most of the zinc produced in California is a by-product either of the lead-silver mines in southeastern California, or of the copper mines. The zinc produced in 1953 totaled 10,716,000 pounds valued at $1,232,340, compared with 18,838,000 pounds valued at $3,127,108 in 1952. Although production at base metal mines was adversely affected by falling prices during 1953, mines in the following counties contributed to the total zinc production: Calaveras, El Dorado, Inyo, Mono, San Bernardino, and Tulare Counties.

DIRECTORY OF MINERAL PRODUCERS IN CALIFORNIA DURING 1952 AND 1953

(Producers of natural gas and petroleum may be found in the Summary of Operations, California Oil Fields, July-Dec. 1953, vol. 39, no. 2, of the State Division of Oil and Gas)

Asbestos

Mine	Operator	Year	Address	Location
Placer County				
Noon Day	Zimdars & Delmue	53	365 Foresthill Ave., Auburn	Iowa Hill
Shasta County				
----------	Mt. Shasta Mining Co.	53	P.O. Box 944, Mt. Shasta	Mt. Shasta
Tuolumne County				
Premier	Premier Asbestos Co,	53	Frank O. Reed, 1130 Encina Dr., Modesto	Jamestown

Barite

Operator	Years	Address	Location
Plumas County:			
Barium Products, Ltd.	52-53	P.O. Box 920, Modesto	Almanor
San Bernardino County:			
Molybdenum Corp. of America	53	Mountain Pass via Nipton	Mountain Pass
Oil Base, Inc.	53	130 Oris St., Compton	Barstow

Borates

Operator	Years	Address	Location
Inyo County:			
Pacific Coast Borax Co.	52-53	P.O. Box 9128, Sta. S, Los Angeles 5	Shoshone
United States Borax Co.	52-53	630 Shatto Pl., Los Angeles 5	Shoshone
Kern County:			
Pacific Coast Borax Co.	52-53	P.O. Box 9128, St. S, Los Angeles 5	Boron
San Bernardino County:			
American Potash and Chemical Corp.	52-53	3030 W. Sixth St., Los Angeles 54	Trona
West End Chemical Co.	52-53	608 Latham Square Bldg., Oakland 12	Westend

Bromine

Operator	Years	Address	Location
Alameda County:			
Westvaco Chemical Division, Food Machinery and Chemical Corp.	52-53	161-E.42nd St., New York, N. Y.	Newark
San Bernardino County:			
American Potash and Chemical Co.	52-53	3030 W. Sixth St., Los Angeles 54	Trona

Calcium Chloride

Operator	Years	Address	Location
San Bernardino County:			
California Salt Co.	52-53	2436 Hunter St., Los Angleles 21	Amboy
Hill Brothers Chemical Co.	52-53	2159 Bay St., Los Angeles 21	Amboy
National Chloride Company of America	52-53	354 S. Spring St., Los Angeles 13	Amboy

Carbon Dioxide Gas

Operator	Years	Address	Location
Imperial County:			
Cardox Corporation	52-53	151 N. Avenue 19, Los Angeles 31	Niland
Mendocino County:			
Cal Dry Ice Corp.	52-53	Old River Rd., Hopland	Hopland

Cement

Operator	Years	Address	Location
Calaveras County:			
Calaveras Cement Co.	52-53	315 Montgomery St., San Francisco 6	San Andreas
Kern County:			
Monolith Portland Cement Co.	52-53	Box 3947, Glassell Sta., Los Angeles 65	Monolith
Los Angeles County:			
Blue Diamond Corp.	52-53	1650 S. Alameda St., Los Angeles 54	Los Angeles
Riverside County:			
Riverside Cement Co.	52-53	621 S. Hope St., Los Angeles 17	Crestmore
San Benito County:			
Pacific Division, Ideal Cement Co.	52-53	620 Denver Nat. Bank Bldg., Denver, Colo.	San Juan Bautista
San Bernardino County:			
California Portland Cement Co.	52-53	612 S. Flower St., Los Angeles 17	Colton
Riverside Cement Co.	52-53	621 S. Hope St. Los Angeles 17	Oro Grande
Southwestern Portland Cement Co.	52-53	1034 Wilshire Blvd., Los Angeles 17	Victorville
San Mateo County:			
Pacific Division, Ideal Cement Co.	52-53	620 Denver Nat. Bank Bldg., Denver 2, Colo.	Redwood City
Santa Clara County:			
Permanente Cement Co.	52-53	Permanente	Permanente
Santa Cruz County:			
Santa Cruz Portland Cement Co.	52-53	324 Crocker Bldg., San Francisco 4	Davenport

Clay

Including producers of crude clay, fire clay, kaolin, bentonite, oil well drilling mud, and miscellaneous clay

Operator	Years	Address	Location
Alameda County:			
California Pottery Co. (miscellaneous clay)	52-53	P.O. Box 68, Niles	Niles
Interlocking Roof Tile Co. (miscellanecus clay and shale)	52-53	Box 488, Niles	Niles
Kraftile Co. (miscellaneous clay)	52-53	Niles	Niles
M & S Tile Co. (miscellaneous clay)	52-53	Second and E Sts., Decoto	Decoto
Amador County:			
Gladding, McBean & Co. (fire clay)	52-53	2901 Los Feliz Blvd., Los Angeles 39	Ione
Pacific Clay Products Co. (fire clay)	52-53	1255 W. Fourth St., Los Angeles	Ione
Western Refractories Co. (fire clay)	52-53	P.O. Box 169, Ione	Ione
Calaveras County:			
California Pottery Co. (miscellaneous clay)	52-53	P.O. Box 68, Niles	Valley Springs
Pacific Clay Products Co. (fire clay)	52-53	1255 W. 4th St., Los Angeles	Valley Springs
Contra Costa County:			
Port Costa Brick Works, C. G. Berg, Pres. (miscellaneous clay and shale)	52-53	401 Berry St., San Francisco 7	Porta Costa
United Materials & Richmond Brick Co., Ltd. (miscellaneous clay and shale)	52-53	Box 7, Richmond 3	Richmond
Fresno County:			
Craycroft Brick Co, (miscellaneous clay)	52-53	P.O. Box 814, Fresno	Fresno
Humbolt County:			
Hindley Clay Products (miscellaneous clay)	52-53	3121 Essex St., Eureka	Cutten
Inyo County:			
Calearth Inc., Ltd. (fullers earth)	52	1608 Huntington Dr., South Pasadena	Olancha
Industrial Minerals & Chemical Co. (bentonite)	52	836 Gilman St., Berkley	Death Valley Junction
Multa Mines, Inc. (fullers earth)	52-53	2552 E. Olympic Blvd., Los Angeles	Tecopa
Sierra Talc & Clay Co. (bentonite and fullers earth)	53	1608 Huntington Drive., South Pasadena	Olancha
Silicates Corp. (bentonite)	52-53	230 Park Ave., New York, N. Y.	Death Valley Junction
Kern County:			
American Mineral Co. (kaolin or china clay)	52-53	840 S. Mission Rd., Los Angeles	Cantil
Excel Minerals Co. (fullers earth)	52-53	3461 E. 26th St., Los Angeles	Taft
Kernco Materials Co. (oil-well drilling mud)	52-53	P.O. Box 1202, Bakersfield	Muroc
Macco Corp., Drilling Mud Division (oil-well drilling mud)	52	14409 S. Paramount Blvd., Paramount	Rosamond
McKittrick Mud Co. (oil-well drilling mud)	52-53	Box 356, McKittrick	McKittrick
Mojave Corp. (oil-well drilling mud)	52-53	12827 E. Imperial Highway, Norwalk	Muroc

Los Angeles County:			
Angulo Tile Co. (miscellaneous clay)	52-53	19044 Kittridge St., Reseda	Reseda
Atkinson Brick Co. (miscellaneous clay)	52-53	13633 Central Ave., Los Angeles 59	Los Angeles
Atlas Sewer Pipe Co, (miscellaneous clay and adobe)	52-53	10009 S. Painter St., Whittier	Whittier
J. C. Booth (miscellaneous clay)	52-53	1775 Stanford Ave., Santa Monica	Santa Monica
Builders Brick Co. (miscellaneous clay)	52-53	P.O. Box 266, Gardena	Compton
Castaic Brick Co. (miscellaneous clay and shale)	52-53	Castaic, P.O. Box 180	Castaic
Davidson Brick Co. (miscellaneous clay)	52-53	4701 Floral Dr., Los Angeles 22	Los Angeles
Gladding McBean & Co. (miscellaneous clay)	52-53	2091 Los Feliz Blvd., Los Angeles 39	Tropico, Los Angeles, Santa Monica and Pico
Higgins Brick & Tile Co. (miscellaneous clay)	52-53	P.O. Box 1125, Sta. A., Gardena	Moneta
Lynn Brick Co. (miscellaneous clay)	53	25901 S. Normande Ave., Harbor City	Harbor City
Pacific Brick Co. (miscellaneous clay and shale)	52-53	P.O. Box 1125, Sta. A., Gardena	Santa Monica
Pacific Clay Products (miscellaneous clay, shale)	52-53	1255 W. 4th St., Los Angeles	Los Angeles and Los Nietos
Pomona Brick Co., S. Bernard Strona (miscellaneous clay and shale)	52	Ninth and Buena Vista, Pomona	Pomona
Sun Valle Tile Kilns (miscellaneous clay, alluvium)	52-53	1258 N. Highland Ave., Los Angeles 38	Reseda
Simons Brick Co., W. R. Simons (miscellaneous clay, shale, and adobe)	52	6677 Anaheim-Telegraph Rd., Los Angeles 22	Los Angeles
Valley Brick & Supply Co. (miscellaneous clay and loam)	52-53	6151 Kester Ave., Van Nuys	Van Nuys
Marin County:			
McNear Brick Co. (miscellaneous clay and shale)	52-53	McNear Point, San Rafael, P.O. Box 119	McNear Point
Mono County:			
Huntley Industrial Minerals (kaolin)	52-53	P.O. Box 305, Bishop	Laws
Orange County:			
I. P. Arnold (kaolin or china clay and fire clay)	52-53	7655 W. Second St., Downey, Los Angeles	El Toro
Gladding McBean & Co. (fire clay)	52-53	2910 Los Feliz Blvd., Los Angeles 26	Irvine, Claymont, Prado
La Bolsa Tile Co. (miscellaneous clay)	52-53	R.F.D. 18404 Gothard St., Huntington Beach	Smeltzer
Pacific Clay Products (miscellaneous clay)	52	1255 W. Fourth St., Los Angeles	Irvine
W. A. Schoeppe (kaolin)	52-53	P,O, Box 101, El Toro	El Toro
Placer County:			
Gladding McBean & Co. (fire clay)	52-53	2901 Los Feliz Blvd., Los Angeles 39	Lincoln
Lincoln Clay Products Co. (fire clay)	52-53	P.O. Box 367, Lincoln	Lincoln
Riverside County:			
Alberhill Coal & Clay Co. (fire clay and misc. clay)	52-53	P.O. Box 14005, Barrington Sta,. Los Angeles 24	Alberhill
Elsinore Clay Co. (fire clay)	53	Box 421, Riverside	Elsinore
Gladding McBean & Co. (fire clay and misc. clay)	52-53	2901 Los Feliz Blvd., Los Angeles 39	Corona and Elsinore
Liston Brick Co, (miscellaneous clay)	52-53	P.O. Box 7, Corona	Corona
Los Angeles Brick & Clay Products Co. (fire clay and miscellaneous clay)	52-53	1078 N. Mission Rd., Los Angeles 54	Alberhill
Pacific Clay Products (fire clay and misc. clay)	52-53	1255 W. 4th St., Los Angeles	Corona
Temescal Clay Co. (fire clay)	52	Suite 309, 6308 Pacific Blvd., Huntington Park	Temescal

Clay—Continued

Operator	Years	Address	Location
Sacramento County:			
Cannon & Co. (fire clay and miscellaneous clay)	52-53	Box 802, Sacramento 4	Ben Ali and Michigan Bar
Harrison Fait (adobe)	52-53	1950 Howe St., North Sacramento 21	North Sacramento
Sacramento Brick Co. (miscellaneous clay and adobe)	52-53	P.O. Box 844, Sacramento 4	Sacramento
Western Refractories Co. (fire clay)	53	P.O. Box 169, Ione	Folsom
San Benito County:			
San Benito Bentonite Co. (bentonite)	52-53	237 Pruenridge Rd., Santa Clara	Tres Pinos
San Bernardino County:			
Baroid Sales Div., National Lead Co. (bentonite)	52-53	3113 E. 26 St., Los Angeles 23	Hector
Gladding McBean & Co. (kaolin or china clay)	52-53	2901 Los Feliz Blvd., Los Angeles 39	Goff
Hancock Brick Yard, C. P. Hancock & Son (miscellaneous clay and adobe)	52-53	Box 421, Riverside	Highgrove
Inerto Co. (bentonite)	52-53	1489 Folsom St., San Francisco 3	Newberry
Marter Mining Co. (miscellaneous clay)	52-53	143 N. Rosemont Blvd., San Gabriel	Bryman
Pomona Brick Co. (kaolin & misc.)	53	P.O. Box 239, Pomona	Chino
Southern California Minerals Co., W. K. Skeoch (kaolin & china clay)	52-53	320 S. Mission Rd., Los Angeles 33	Goff
San Diego County:			
La Jolla Canyon Clay Products (miscellaneous clay)	52-53	P.O. Box 712, La Jolla	La Jolla
Union Brick Co. (miscellaneous clay and shale)	52-53	7351 Pacific Highway, San Diego 9	Rose Canyon
San Joaquin County:			
Stockton Brick & Tile Co. (miscellaneous clay)	52-53	P.O. Box 547, Stockton	Stockton
Stockton Building Materials (miscellaneous clay)	52-53	711 S. Madison St., Stockton 4	Stockton
Santa Barbara County:			
Airox Co. (misc. clay)	53	307 W. 8th St., Los Angeles	Santa Maria
McNall Building Materials (misc. clay and shale)	52-53	P.O. Box 758, Santa Barbara	Santa Barbara
Santa Clara County:			
Gladding Bros. Mfg. Co. (miscellaneous clay and fire clay)	52-53	S. Third and Keyes St., San Jose 12	San Jose
Remillard-Dandini Co. (miscellaneous clay)	52-53	321 13th St., Oakland 12	San Jose
San Jose Brick & Tile Co. (miscellaneous clay)	52-53	321 13th St., Oakland 12	San Jose
Sonoma County:			
Basalt Rock Co. (miscellaneous clay)	53	P.O. Box 5401, Napa	Chabot Acres
Stanislaus County:			
Harry Chase (fire clay)	52-53	Box 37, Knights Ferry	Knights Ferry
Lester Raggio (fire clay)	52-53	Box 22, Knights Ferry	Cooperstown

Harry Chase (fire clay)	52-53	Box 37, Knights Ferry	Knights Ferry
Lester Raggio (fire clay)	52-53	Box 22 Knights Ferry	Cooperstown
Sutter County:			
Gladding McBean & Co. (miscellaenous clay)	52-53	2901 Los Feliz Blvd., Los Angeles 26	Nicolaus
Tulare County:			
S. P. Brick & Tile Co. (miscellaneous clay)	52-53	P.O. Box 1372, Fresno	Exeter
Ventura County:			
Rocklite Products (shale)	52-53	1800 N. Ventura Ave., Ventura	Ventura
Shell Oil Co., Dent Clay Pit (oil-well drilling mud	52-53	Shell Bldg., San Francisco	Ventura
Tidewater Associated Oil Co. (oil-well drilling mud)	52-53	79 New Montgomery St., San Francisco	Ventura

Coal

Operator	Years	Address	Location
Amador County:			
American Lignite Products Co.	52-53	Ione	Ione

Diatomite (Diatomaceous Earth)

Operator	Years	Address	Location
Inyo County:			
Hazen Mining Co.	52-53	Independence	Independence
Los Angeles County:			
Great Lakes Carbon Corp., Dicalite Division	52-53	612 S. Flower St., Los Angeles 17	San Pedro
Napa County:			
Basalt Rock Co., Ltd.	53	Eighth and River Sts., Napa	Napa
Santa Barbara County:			
Great Lakes Carbon Corp., Dicalite Division	52-53	612 S. Flower St., Los Angeles 17	Lompoc
Johns-Manville Products Corp.	52-53	22 E. 40th St., New York 16, N. Y.	Lompoc
Stanislaus County:			
Simon Newman Co. (owner)	52	Newman	Newman

Feldspar

Operator	Years	Address	Location
Monterey County:			
Del Monte Properties Co.	52-53	620 Market St., San Francisco	Pacific Grove
San Bernardino County:			
Gladding McBean & Co.	52-53	2901 Los Feliz Blvd., Los Angeles 39	Atolia

Granite (Dimension Stone)

Operator	Years	Address	Location
Fresno County:			
Clovis Quarries, Inc.	53	P.O. Box 68, Clovis	Clovis
Superior Academy Granite Co.	52-53	Box 68, Clovis	Academy
Lassen County:			
J. B. Wagender	52	805 Weatherlow St., Susanville	Susanville
Madera County:			
Raymond Granite Quarries, D. J. McCarthy	52-53	6690 Foothill Blvd., Oakland	Raymond
Placer County:			
Union Granite	52-53	P.O. Box 819, Rocklin	Rocklin
San Bernardino County:			
W. H. Johnson and Co.	52-53	Box 605, Victorville	Victorville
San Diego County:			
California Cut Stone	52-53	Railroad Ave. at Magnolia, South San Francisco	Vista
D. B. Clemens		3600 Suncrest Blvd., El Cajon	Suncrest
Escondido Quarries, Inc.	52-53	530 W. Sixth St., Los Angeles	Escondido
National Quarries	52	923 Park Hill Dr., Escondido	Escondido
Southern California Granite Co.	52	3845 Imperial Ave., San Diego 13	Foster
Valley Granite Co.	52-53	243 E. Fifth St., Escondido	Escondido

Gypsum

Operator	Years	Address	Location
Alameda County:			
Westvaco Chemical Division, Food Machinery & Chemical Corp. (output not included in production figures as gypsum is by-product of chemical process using minerals already included in state total)	52-53	161 E. 42nd St., New York, N. Y.	Newark
Fresno County:			
Valley View Gypsum Mine, Edward Jones	52-53	P.O. Box 887, Dos Palos	Firebaugh
Imperial County:			
United States Gypsum Co.	52-53	300 W. Adams St., Chicago, Ill.	Plaster City
Kern County:			
Carrisa Gypsum Mine, C. L. Fannin	52-53	Route 1, Box 7, Wasco	Wasco
D. F. Halsey	53	Rosamond	Cantil
H. M. Holloway	52-53	714 Sixth St., Wasco	Lost Hills
Mojave Desert Agricultural Gypsum, J. R. Canady	53	Rt. 2, Box 303, Lancaster	Cantil
Purity Gypsum Mine, C. F. Casida	53	715 34th St., Bakersfield	Bakersfield
Roberts Farm Gypsum Mine	52-53	P.O. Box 307, McFarland	McFarland
Western Gypsum Co.	52-53	773 Maple St., Wasco	McKittrick
Kings County:			
H. M. Holloway	52-53	714 Sixth St., Wasco	Avenal
McPhaill Gypsum Co.	52-53	P.O. Box 927, Visalia	Avenal
Merced County:			
Agricultural Mineral & Fertilizer Co., A. D. Sousa	52-53	P.O. Box 832, Los Banos	Los Banos
Riverside County:			
United States Gypsum Co.	52-53	300 W. Adams St., Chicago 6, Ill.	Midland
San Bernardino County:			
Agricultural Minerals Mining Corp.	53	Bristol Lake, Amboy	Bristol Lake
San Luis Obispo County:			
Shandon Gypsum Co.	52-53	P.O. Box 135, Shandon	Shandon
Superior Gypsum Co.	52-53	3916 Pierce Rd., Bakersfield	Carrisa Plains
Ventura County:			
Monolith Portland Cement Co.	52-53	Box 3947 Glassell Sta., Los Angeles 65	Quatal Canyon

Iodine

Operator	Years	Address	Location
Los Angeles County:			
Deepwater Chemical Co., Ltd.	52-53	Box 588, Compton	Compton
Great Western Division, The Dow Chemical Company	52-53	Midland, Mich.	Long Beach, Venice, and Seal Beach

Lime, Limestones, and Shells

Operator	Years	Address	Location
El Dorado County:			
California Rock & Gravel Co. (industrial limestone)	52-53	1800 Hobart Bldg., San Francisco 4	Newcastle
Diamond Springs Lime Corp. (producer of burnt lime, industrial limestone, and agricultural lime)	52-53	Box 409, Diamond Springs	Diamond Springs
El Dorado Limestone Co. (industrial lime)	52-53	Shingle Springs	Shingle Springs
Hughes-Vertin Lime Co. (producer of burnt lime, industrial limestone, agricultural lime, and lime materials used in rough construction)	52-53	Box 231, Auburn	Newcastle
Fresno County:			
Marlife Co. (marl)	53	4304 Belmont Ave., Fresno	Mendota
Kern County:			
Fred Bower (roofing rock)	53	P.O, Box 7, Inyokern	Inyokern
Monterey County:			
Kaiser Aluminum & Chemical Corp. (producer of burnt lime and dolomite)	52-53	Box 1531, Salinas	Salinas
Riverside County:			
Riverside Cement Co. (industrial limestone)	52-53	621 S. Hope St., Los Angeles 17	Crestmore
San Benito County:			
Westvaco Chemical Div., Food Machinery Corp. (dolomite)	52-53	P.O. Box 337, Newark	Hollister
San Bernardino County:			
California Dolomite Co. (refractory dolomite)	52-53	929 E. Artesia, Bellflower	Adelanto, Kramer
California Portland Cement Co. (producer of burnt lime and industrial limestone)	52-53	612 S. Flower St., Los Angeles 17	Colton
Riverside Cement Co. (industrial limestone)	52-53	621 S. Hope St., Los Angeles 17	Oro Grande
Victorville Lime Rock Co. (industrial limestone)	52-53	Box 548, Victorville	Victorville
West End Chemical Co. (producer of burnt lime, and industrial limestone	52-53	608 Latham Square, Oakland 12	Westend
White Lime Rock Co. (industrial limestone)	52-53	5953 Crenshaw Blvd., Los Angeles 43	Victorville

San Diego County:			
Valley Limestone Products Co. (roofing granules)	52	Rt. 1, Box 178, Alpine	Alpine
San Luis Obispo County:			
Henry C. Dalessi (sugar rock)	52-53	Box 465, San Luis Obispo	Lime Mountain
San Mateo County:			
California Aggregates (crushed limestone)	52-53	185 Bayshore Blvd., San Francisco	Rockaway Beach
Skyline Materials, Inc. (crushed limestone)	52-53	P.O. Box 278, Belmont	Belmont
Santa Barbara County:			
G. Antonlini & Sons (building stone)	52	131 E. Gutierrez St., Santa Barbara	Santa Maria
Santa Clara County:			
Bay Shell Co. (agricultural lime and shells)	52	1583 E. 14th St., San Leandro	Alviso
Bahr & Ledoyen, Inc. (crushed limestone)	53	3291 Third St., Palo Alto	Palo Alto
R. J. Gambetta (shells)	53	Scott Lane, Santa Clara	Santa Clara
Santa Cruz County:			
Pacific Limestone Prod. Co. (industrial limestone and agricultural lime)	52-53	445 Spring St., Santa Cruz	Santa Cruz
Santa Cruz Portland Cement Co. (industrial limestone)	52-53	327 Crocker Bldg., San Francisco	Davenport
Shasta County:			
H. L. Wadell (agricultural and crushed limestone)	52	Box 1622, Redding	Redding
Tuolumne County:			
Sonora Marble Aggregates Co. (industrial limestone)	52-53	211 S. Maple, South San Francisco	Sonora
U. S. Lime Products Corp. (producers of burnt lime, industrial limestone, agricultural lime, and dolomite)	52-53	175 S. Alvarado St., Los Angeles 4	Sonora
Ventura County:			
Western Lime Products Co. (industrial limestone and agricultural lime)	52-53	102 N. Brand Blvd., Glendale 3	Santa Susana

Lithia

Operator	Years	Address	Location
San Bernardino County:			
American Potash & Chemical Corp.	52-53	3030 W. Sixth St., Los Angeles 54	Trona

Magnesite

Operator	Years	Address	Location
Santa Clara County:			
James McPeters	52	Star Route, Box 39, Livermore	Red Mountain
Westvaco Chemical Division, Food Machinery & Chemical Corp.	52	161 E. 42d St., New York 17, N. Y.	Red Mountain

Magnesia and Other Magnesium Compounds

Operator	Years	Address	Location
Alameda County:			
Pabco Products, Inc. (carbonate)	52-53	1550 Powell St., Emeryville 8	Emeryville
Westvaco Chemical Division, Food Machinery & Chemical Corp. (oxide)	52-53	161 E. 42d St., New York, N. Y.	Newark
Monterey County:			
Kaiser Aluminum & Chemical Corp. (oxide)	52-53	Box 1531, Salinas	Moss Landing
San Diego County:			
Westvaco Chemical Division, Food Machinery & Chemical Corp. (chloride)	52-53	161 E. 42d St., New York, N. Y.	Chula Vista
San Mateo County:			
Johns-Manville Products Corp. (carbonate)	52-53	22 E. 40th St., New York 16, N. Y.	Redwood City
Marine Magnesia Products Division, Merck & Co., Inc. (carbonate, hydroxide, and oxide)	52-53	E. Grand Ave., South San Francisco	South San Francisco

Peat

Operator	Years	Address	Location
Contra Costa County:			
Pacific Natural Products Co., F. Koser	52-53	P.O. Box 1201, Richmond	Antioch
Modoc County:			
Modoc Peat Moss Co.	53	604 Mission St., San Francisco 5	Likely
Organic Factors & Chemical Co.	52	P.O. Box 323, French Camp	Likely
Orange County:			
R. W. McClellan and Sons	52-53	151 Commercial Way, Costa Mesa	Costa Mesa
Peat Sales Co., D. M. Callis, Jr.	52-53	17581 Gothard Rd., Huntington Beach	Huntington Beach

Perlite

Operator	Years	Address	Location
Contra Costa County:			
American Perlite Corp. (expanded)	52-53	26th and B Sts., Richmond	Richmond
Fresno County:			
Perlite Products (expanded)	53	93 Van Ness Ave., Fresno	Fresno
Inyo County:			
U. S. Mining Corp. (crude)	52-53	5858 Wilshire Blvd., Los Angeles 36	Fish Springs
Los Angeles County:			
Great Lakes Carbon Corp. (expanded)	52	18 E. 48th St., New York, N. Y.	Torrance
McClure & Erickson (expanded)	53	2416 Bedessen Ave., Los Angeles	Los Angeles
Panacalite Pacific, Inc. (expanded)	52-53	825 E. 60th St. Los Angeles 11	Los Angeles
Paramount Perlite Co., Inc. (expanded)	52-53	16236 S. Illinois, Paramount	Paramount
Peerless Perlite Co. (expanded)	52-53	2807 S. Fairfax, Los Angeles 16	Los Angeles
Perlite Popped Products (expanded)	53	2744 Auburn St., Los Angeles 39	Los Angeles
Redco, Inc. (expanded)	52-53	11831 Vose St., North Hollywood	North Hollywood
Sun Perl Corp. (expanded)	53	Sun Valley	Sun Valley
U. S. Perlite Mfg. Co. (expanded)	52-53	612 S. Flower St., Los Angeles 17	Los Angeles
Marin County:			
Perolite Products Corp. (expanded)	52-53	P.O. Box 175, Sausalito	Sausalito
Napa County:			
Napa Perlite Co. (crude)	52-53	300 Montgomery St., San Francisco	St. Helena
Perlite Aggregates, Inc. (crude and expanded)	52-53	St. Helena	St. Helena
Richmond Perlite Co. (expanded)	52	1057 Main St., St. Helena	St. Helena
Riverside County:			
More-Lite Co. (expanded)	52-53	R.D. 5, Box 101-B, Crestmore via Riverside	Crestmore
San Bernardino County:			
California Perlite Corp. (crude)	53	R. 240, 35 N. Raymond Ave., Pasadena	Ludlow
More-Lite (crude)	52	P.O. Box 101B, R.D. 5, Riverside	Nipton
Nulite Insulated Homes, Inc. (expanded)	52-53	Box 216, Fontana	Fontana
San Diego County:			
Harborlite Corp. (expanded)	52-53	696 Montgomery Freeway, Chula Vista	Chula Vista

Potash

Operator	Years	Address	Location
San Bernardino County:			
American Potash and Chemical Co.	52-53	3030 W. Sixth St., Los Angeles 54	Trona

Pumice and Pumicite

Operator	Years	Address	Location
Amador County:			
Gladding McBean & Co. (pumice)	53	2901 Los Feliz Blvd., Los Angeles	Ione
Calaveras County:			
H. D. Warren Pumice Plant (pumice)	52-53	Rt. 1, Box 295, Linden	Burson
Imperial County:			
Superlite Corp. (pumice)	52-53	P.O. Box BB, Calipatria	Calipatria
Inyo County:			
Bishop Building Materials (pumicite)	53	P.O. Box 1013, Bishop	Bishop
Crownite Corp. (pumice)	52-53	6363 Wilshire Blvd., Los Angeles 48	Coso Junction
H. B. Jarvis (pumice)	52	P.O. Box 5, Little Lake	Little Lake
Redlite Aggregates Co. (volcanic cinders)	53	Little Lake	Little Lake
Kern County:			
Calsilco Corp. (pumice, pumicite, or volcanic ash)	52-53	2372 S. Atlantic Blvd., Los Angeles	Red Rock Canyon
Madera County:			
California Industrial Mineral Co. (pumicite or volcanic ash)	52-53	P.O. Box 188, Friant	Friant
Elmer Erickson (pumice)	52-53	P.O. Box 98, Friant	Friant
Modoc County:			
Glass Mountain Brick Co. (pumice)	52-53	Star Rt. 2, Box 10, Tulelake	Tulelake
Glass Mountain Pumice Products (pumice)	53	P.O. Box 481, Tulelake	Glass Mountain
Glass Mt. Volcolite Co., H. W. Free (pumice)	52	Tionesta	Glass Mountain

Mono County:			
Bishop Hardware & Supply Co. (pumice)	52	Box 1013, Bishop	Laws
Cowan & McGraw (pumice)	53	P.O. Box 1013, Bishop	Benton
Insulating Aggregate Co., G. M. M. Grant (pumice)	52-53	Box 884, Bishop	Laws
U. S. Pumice Supply Co. (pumice, scouring blocks)	52-53	6331 Hollywood Blvd., Los Angeles 28	Lee Vining
Napa County:			
Basalt Rock Co. (pumice)	52	P.O. Box 540, Napa	Napa
San Bernardino County:			
Neal Garrett (pumice)	53	1304 Carment Dr., Glendale 7	Newberry
Harry F. Heather (pumice)	52-53	236 S. Oak Knoll Ave., Pasadena 5	Newberry
Western Talc Co. (pumicite or volcanic ash)	52	1901 E. Slauson Ave., Los Angeles 58	Yermo
Williams Bros. (pumice)	52-53	Star Route 1, Barstow	Hinkley
Siskiyou County:			
Boorman Pumice Products (pumice)	52-53	Tionesta	Glass Mountain
Gordenker Pumice Co. (pumice)	52-53	Tionesta	Glass Mountain
Glass Mt. Volcolite Co., H. W. Free (pumice, scouring blocks)	52	Tionesta	Glass Mountain
McCloud River Line (volcanic cinders)	53	McCloud	Hambone
John Madsen (Skoria Star Brick Co.) (pumice, scouring blocks)	52-53	P.O. Box 711, Klamath Falls, Ore.	Glass Mountain
Shastalite Block Co. (pumice)	52-53	P.O. Box 914, Yreka	Cinder Cone Mountain
U. S. Pumice Supply Co., Inc. (pumice)	52-53	6331 Hollywood Blvd., Los Angeles 28	Glass Mountain
Dan Williams (pumice)	53	221 Katherine St., Salinas	Mt. Hoffman

Pyrite

Operator	Years	Address	Location
Shasta County:			
The Mountain Copper Co., Ltd., L. T. T. Kett, Jr., Mgr.	52-53	230 California St., San Francisco 4	Matheson

Salt

Operator	Years	Address	Location
Alameda County:			
American Salt Co.	52-53	341 Broadway, San Francisco 11	Mt. Eden
Leslie Salt Co.	52-53	505 Beach St., San Francisco 11	Newark and Mt. Eden
Morton Salt Co.	52-53	120 S. La Salle St., Chicago, Ill.	Newark
Oliver Bros. Salt Co.	52-53	P.O. Box 132, Mt. Eden	Mt. Eden
Kern County:			
Long Beach Salt Co.	52-53	2476 Hunter St., Long Beach 21	Randsburg
Monterey County:			
Monterey Bay Salt Works, E. C. Vierra, Mgr.	52-53	Box 43A, Moss Landing	Moss Landing
Orange County:			
Western Salt Co.	52-53	P.O. Box 149, San Diego 12	Newport Beach
San Bernardino County:			
California Salt Co.	52-53	2436 Hunter St., Los Angeles 21	Amboy
Dale Chemical Industries, Inc.	52	Goodwin Ave., Los Angeles 26	Dale Lake
Don's Salt Service	53	Twentynine Palms	Twentynine Palms
Pacific Salt & Chemical Co.	52-53	1517 E. Olympic Blvd., Los Angeles 21	Trona
San Diego County:			
Western Salt Co.	52-53	P.O. Box 149, San Diego 12	Chula Vista

Sand, Gravel, and Stone, Miscellaneous

Under the heading of "miscellaneous stone" are four divisions—crushed rock, grinding mill pebbles, paving blocks, and sand and gravel. Crushed rock includes crushed rock that is used in macadam, ballast, and for concrete; also rock used for rubble and riprap.

NOTE—The California State Highway Commission, the various counties, cities, U. S. Engineers, U. S. Bureau of Reclamation, U. S. Forest Service, U. S. National Park Service, and U. S. Bureau of Public Roads produce both crushed rock and sand and gravel in various places in the state used in construction and maintenance of highways, but not specified in this listing.

Operator	Years	Address	Location
Alameda County:			
Bell Sand & Gravel, Stanley L. and Anna L. Bell (sand and gravel)	52-53	P.O. Box 282, Irvington	Irvington
California Rock & Gravel Co. (sand and gravel)	52-53	1800 Hobart Bldg., San Francisco	Livermore
Gallagher & Burk, Inc. (crushed rock-macadam, fill rock, ballast)	52-53	344 High St., Oakland	Oakland
Henry J. Kaiser Co. (sand and gravel, crushed rock)	52-53	Kaiser Bldg., 1924 Broadway, Oakland	Radum and Niles
Leslie Salt Co. (riprap)	52	505 Beach St., San Francisco	Newark

Niles Quarry Co. (crushed rock, fill rock)	52-53	Box 507A, 4061 Highland Blvd., Niles	Niles
Pacific Coast Aggregates, Inc. (sand and gravel, crushed rock)	52-53	400 Alabama St., San Francisco	Eliot and Centerville
Rhodes & Jamieson, Ltd. (sand and gravel)	52-53	333 23d Ave., Oakland 4	Centerville
San Leandro Rock Co. (crushed rock, fill rock)	52-53	1575 Lake Chabot Rd., San Leandro	Lake Chabot
Butte County:			
Butte Creek Rock Co. (sand and gravel)	52-53	Centerville Rd. Chico	Chico
Gene Holland (sand and gravel)	53	c/o Ord Ferry Stage, Chico	Ord Ferry
Henry J. Kaiser Co. (sand and gravel, crushed rock—macadam, ballast, rubble, riprap, etc.)	52-53	1924 Broadway, Oakland	Oroville
Marler Rock (sand and gravel)	53	Rt. 2, Box 721, Oroville	Oroville
Roy Mathews Gravel Plant (sand and gravel)	52-53	Rt. 1, Box 23, Gridley	Gridley
Pentz Gravel (sand and gravel	52	Oroville	Oroville
Calaveras County:			
Neilsen Sand & Gravel Co. (sand and gravel)	52-53	Box 457, San Andreas	San Andreas
Colusa County:			
Cortina Sand, Gravel and Silt; Gene Godin (sand and gravel)	52-53	P.O. Box 357, Colusa	Colusa
Paul Entremont (sand and gravel)	52-53	Box 208, Colusa	Wohlfrem Ranch
C. W. & D. O. McKasson (sand and gravel)	52	Rt. 1, Box 11, Colusa	Princeton
Contra Costa County:			
Basalt Rock Co. (sand and gravel)	52	Eighth and River Sts., Napa	Antioch
Blake Bros., Anson Blake (crushed rock, ballast, riprap)	52-53	Box 1002, Richmond	Point Richmond
Henry J. Kaiser Co. (sand and gravel, crushed rock)	52-53	1924 Broadway, Oakland	Antioch
Marchio Silica Sand (molding sand)	52-53	Oil Canyon Rd., Antioch	Antioch
Morris Sand Pit, Ben Morris (sand and gravel)	52-53	Rt. 1, Box 660, Antioch	Antioch
Serra Bros. (crushed rock, fill rock)	52-53	R. F. D. Rt. 1, Box 355, Martinez	Walnut Creek
Tunnel Rock Quarry (crushed rock)	53	220 Tunnel Rd., Orinda	Orinda
Del Norte County:			
Crescent City Rock Co. (gravel)	53	Crescent City	Fort Dick
Peters Rock Co. (sand and gravel)	53	Crescent City	Crescent City
Rowdy Creek Crusher Co. (crushed rock)	53	Smith River	Smith River
Simpson Logging Co. (sand and gravel)	52-53	Klamath	Klamath
Marlin Tryon Co. (sand and gravel)	52-53	P.O. Box 36, Fort Dick	Fort Dick
El Dorado County:			
El Dorado Rock & Sand (sand and gravel)	52-53	57 Coloma St., Placerville	Placerville
Diamond Springs Lime Co. (crushed rock—macadam)	52-53	Diamond Springs	Diamond Springs
T. C. Nutt Quarry (flagstone)	52	Box 9, Placerville	Placerville
Ralph C. Young (flagstone)	52	Rt. 3, Box 252, Placerville	Placerville
Fresno County:			
Anderson Rock Plant (sand and gravel)	53	Rt. 1, Box 581, Fresno	Fresno
Atchison, Topeka & Santa Fe Railway Co. (ballast, sand and gravel)	52-53	121 E. Sixth St., Los Angeles 14	Oakhurst, Piedra
Central Rock & Sand Co. (sand and gravel)	52-53	P.O. Box 425, Sanger	Sanger
L. D. Folsom (sand and gravel)	52-53	Box 347, Coalinga	Coalinga

Sand, Gravel, and Stone, Miscellaneous—Continued

Operator	Years	Address	Location
Herndon Rock Products Co. (sand and gravel, crushed rock)	52-53	410 Thorne St., P.O. Box 886, Fresno	Herndon
Pacific Coast Aggregates, Inc., (sand and gravel, crushed rock)	52-53	400 Alabama St., San Francisco	Rockfield
Gene Richards, Inc. (sand and gravel)	53	355 Thorne St., Fresno	
Sanger Rock & Sand (sand and gravel)	52-53	17125 E. Kings Canyon Rd., Sanger	Sanger
Sharp & Fellows Construction Co. (crushed rock—macadam, ballast)	52-53	533 Central Bldg., Los Angeles 14	Piedra
Southern California Edison Co. (sand and gravel)	53	601 W. Fifth St., Los Angeles 53	Vermillion Valley Dam
Thompson Materials (sand and gravel)	52-53	Bin J, Avenal	Coalinga
Glenn County:			
L. G. Madsen & L. J. Paul (sand and gravel)	52-53	246 Plumas St., Willows	Willows
Orland Sand & Gravel Co. (sand and gravel)	52-53	P.O. Box 916, Orland	Wyo
W. J. Rabbett (sand and gravel)	52-53	Rt. 1, Box 25, Willows	Willows
Southern Pacific Co. (sand and gravel)	52-53	65 Market St., San Francisco	Wyo
Humbolt County:			
Eureka Sand & Gravel Co.(sand and gravel)	52-53	1920 Williams St., Eureka	Eureka
Tom Hull (riprap)	53	930 Carson St., Eureka	Blue lake
Anne Chapman (sand and gravel)	52	Klamath	
Kelly & McWhorter (sand and gravel)	52-53	P.O. Box 572, Fortuna	Eureka
Mad River Sand & Gravel Co. (sand and gravel)	52-53	P.O. Box 428, Arcata	Arcata
McWhorter & Dougherty (sand and gravel and railroad ballast)	53	P.O. Box 542, Fortuna	Fortuna
Mercer Fraser Co., Inc. (sand and gravel)	52	Second and Commercial Sts., Eureka	Essex and Fernbridge
Northwestern Pacific R.R. Co. (sand and gravel)	52	San Rafael	Sequoia
Imperial County:			
Valley Transit Cement Co., Inc. (sand and gravel)	52-53	P.O. Box 1489, El Centro	El Centro
Western Non-Metallics (roofing granules)	53	109 N. Vineland, Puente	Puente
Kern County:			
C & H Materials Co. (sand and gravel)	52-53	P.O. Box 1632, Bakersfield	Bakersfield
Griffith Co. (sand and gravel)	52-53	Box 175, Sta. B, Bakersfield	Bakersfield
Hartman Concrete Materials (sand and gravel)	52-53	P,O, Box 1632, Bakersfield	Bakersfield and Maricopa
Kern Rock Co., Ltd. (sand and gravel, and crushed rock)	52-53	P.O. Box 1697, Bakersfield	Kern River
Lake County:			
F. M. Feazell (sand and gravel)	53	P.O. Box 914, Lakeport	Kelseyville
Lange Bros. Sand and Gravel Plant, H. Lange & A. Lange (sand and gravel)	52-53	Box 66, Lakeport	Kelseyville
Lassen County:			
Grayson Concrete & Materials (sand and gravel)	52	1512 Fourth St., Susanville	Susanville
Los Angeles County:			
Arrow Rock Co. (sand and gravel)	52-53	11670 Wicks St., Sun Valley	Monrovia and Sun Valley

Azusa Rock & Sand Co. (sand and gravel, crushed rock)	52-53	P.O. Box 575, Azusa	Azusa
Richard R. Ball (sand and gravel, filter sand)	52	Box 96, Walteria	Walteria
Blue Diamond Corp., Ltd. (sand and gravel)	52-53	1650 S. Alameda St., Los Angeles 54	El Monte and Sun Valley
Wm. J. Bonfield (decomposed granite)	52-53	2008 Laurel Canyon Rd., Los Angeles 46	Sun Valley
California Materials Co. (sand and gravel, and crushed rock)	52-53	P.O. Box 110, Whittier	Whittier
Century Rock Products (sand and gravel)	53	5501 N. Peck Rd., El Monte	El Monte
Chandler Sand & Gravel, L. Chandler (sand and gravel)	52-53	Box 295, Lomita	Lomita
City Rock Co. (sand and gravel, crushed rock)	52-53	P.O. Box 8, Sunland	Sunland
Connolly-Case-Kiewit Co. (crushed rock)	52	2051 Del Amo Blvd., Compton	--------
Connolly-Pacific Co. (riprap)	53	1925 Water St., Long Beach	Catalina Island
Consolidated Rock Products Co. (sand and gravel, crushed rock)	52-53	Box 2950 Terminal Annex or 2730 S. Alameda St., Los Angeles	Los Angeles, Azusa, Roscoe, Monroe, Monrovia, Baldwin Park, and North Hollywood
Gordon Transfer Co. (sand and gravel)	52-53	209 W. Acacia, El Segundo	El Segundo
Graham Bros., Inc. (sand and gravel, and crushed rock)	52-53	5500 N. Peck Rd., El Monte	El Monte
Granite Materials Co. (sand and gravel, decomposed granite)	52-53	P.O. Box 368, Roscoe	Roscoe
Hanawalts (crushed rock, sand and gravel)	52-53	4594 San Bernardino Ave., LaVerne	Pomona
Lindauer Corp. (sand and gravel)	52-53	Box 337, La Habra	La Habra
Livingston Rock & Gravel Co. (sand and gravel, riprap and crushed rock)	52-53	3366 Cherry Ave., Long Beach 7	Azusa and Palos Verdes
Livingston Truck & Materials Co. (decomposed granite)	52-53	3366 Cherry Ave., Long Beach 7	Rolling Hills
Los Angeles Decomposed Granite Co. (decomposed granite)	52-53	Box 39, Montebello	Montebello
MacArthur & Son (sand and gravel)	52-53	P.O. Box 82, Palmdale	Palmdale
Wm. R. Magoffin dba Caswell & Co. (sand and gravel)	52	2357 E. Slauson Ave., Los Angeles 58	Torrance
Manning Bros. Rock & Sand Co. (sand and gravel, crushed rock)	52-53	P.O. Box C, Irwindale	Irwindale
Miller Bros. Truck Co. (sand and gravel)	52-53	3451 Randolph St., Huntington Park	Huntington Park
Osburn Co. (sand and gravel)	52-53	3200 Edgecliff Lane, Pasadena	Pasadena
Owl Rock Products Co. (sand and gravel)	52-53	P.O. Box 509. Compton	Monrovia
Pacific Rock & Gravel Co. (sand and gravel)	52-53	Box 778, Arcadia	Monrovia
Walter Ranson (sand and gravel)	52-53	3467 Greenfield Ave., Los Angeles 34	El Segundo
Edward Sidebotham & Sons, Inc. (sand and gravel)	52-53	751 E. "L" St., Wilmington	Lomita
Sierra Rock Products (sand and gravel)	52-53	P.O. Box 216, Temple City	Temple City
Sparks & Mundo Engineering Co. (sand and gravel)	52-53	1711 S. Soto St., Los Angeles 23	Monrovia
Madera County:			
Cy Perkinson Concrete Suppliers (sand and gravel)	52	Rt. 1, Box 2, Chowchilla	Chowchilla
San Joaquin Valley Pipe Co. (sand and gravel)	52-53	P.O. Box 215, Chowchilla	Chowchilla
Thompson Materials & Construction Co., Inc. (sand and gravel)	53	917 Dome St., Avenal	Madera
Valley Feed & Fuel Co. (sand and gravel)	52-53	121 N. "F" St., Madera	Madera
Marin County:			
Basalt Rock Co. (crushed rock, riprap)	52-53	Eighth and River Sts., Napa	McNear Point
Hutchinson Co. (crushed rock—macadam, rubble, riprap)	52-53	7360 Schmidt Lane, El Cerrito	San Rafael
Mariposa County:			
Geo. P., J. G., and E. C. Greenamger (sand and gravel)	52-53	Box N. Mariposa	Mariposa
Wm. J. Saye (sand and gravel)	52-53	P.O. Box 60, Mariposa	Mariposa

Sand, Gravel, and Stone, Miscellaneous—Continued

Operator	Years	Address	Location
Mendocino County:			
Ford Gravel Co. (sand and gravel)	53	P.O. Box 217, Ukiah	Ukiah
Ukiah Gravel & Cement Co., Inc. (sand and gravel)	52-53	P.O. Box 187, Ukiah	Ukiah
E. Walsh and M. Ford (sand and gravel)	52	Box 74, Ukiah	Ukiah
Merced County:			
Cressey Sand & Gravel Plant (sand and gravel)	53	Rt. 2, Box 360, Merced	Cressey
Le Grand Sand & Gravel, c/o Hammer Bros. (sand and gravel)	53	P.O. Box 232, Le Grand	Le Grand
Los Banos Gravel Co. (sand and gravel)	52-53	P.O. Box 1111, Los Banos	Los Banos
River Rock Co. (sand and gravel)	52-53	20 E. 15th St., Merced	Merced
Turlock Rock Co. (sand and gravel)	52-53	P.O. Box 548, Turlock	Balico
Valley Aggregates, Inc. (sand and gravel)	53	P.O. Box 744, Merced	Cressey
Volpa Bros. (sand and gravel)	53	233 Neilson, Fresno	Le Grand
Monterey County:			
Max Cozin (sand and gravel)	52-53	Box 9, Metz Rt., King City	King City
Del Monte Properties Co. (sand and gravel, molding sand)	52-53	P.O. Box 150, Pacific Grove	Pacific Grove
Monterey Sand Co. (sand and gravel, filter sand)	52-53	Box 928, Monterey	Seaside
M. J. Murphy, Inc. (sand and gravel)	52-53	P.O. Box 100, Carmel	Carmel
Owens Illinois Glass Co. (glass sand)	52-53	350 Sansome St., San Francisco	Pacific Grove
Pacific Coast Aggregates, Inc.	52-53	400 Alabama St., San Francisco	Lapis and Prattco
Napa County:			
Basalt Rock Co. (crushed rock—macadam, riprap)	52-53	Eighth and River Sts., Napa	Napa
Benson Gravel Plant (sand and gravel)	53	P.O. Box 341, Angwin	Pope Valley
Nevada County:			
Greenhorn Sand & Gravel Co. (sand and gravel)	53	Grass Valley	Grass Valley
Bob Winkle (sand and gravel)	53	Grass Valley	Grass Valley
Orange County:			
I. P. Arnold (sand)	52-53	7655 E. Second St., Downey	Santa Ana
Burris Sand Pit, Geo. T. Calhoun (sand)	52-53	Box 1741, Santa Ana	Anaheim
California Rock Co. (sand and gravel)	52-53	Rt. 3, Box 12111, Orange	Orange
Consolidated Rock Products Co. (sand and gravel, crushed rock—macadam, ballast, rubble, riprap, etc.)	52-53	2730 S. Alameda St., Los Angeles	Fullerton and Orange
Foster Sand & Gravel (sand and gravel)	52-53	915 S. Spadra Rd., Fullerton	Orange
A. E. Fowler & Sons (sand and gravel)	52-53	Rt. 3, 12705 Cambridge St., Orange	Orange
V. J. Frye (molding sand)	53	1320 N. Flower St., Santa Ana	New Port Beach
Graham Bros., Inc. (sand and gravel, crushed rock—macadam, ballast, rubble, riprap, etc.)	52-53	5500 N. Peck Rd., El Monte	San Juan Capistrano
D. D. Lawhead & Sons (decomposed granite)	52-53	Seal Beach	Buena Park
R. J. Noble Co. (sand and gravel)	52-53	P.O. Box 620 Orange	Orange

Orange County Rock Products (sand and gravel)	53	P.O. Box 125, Artesia	Artesia
McClelland & Son (sand and gravel)	52-53	151 Commercial Way, Costa Mesa	Anaheim
Sully-Miller Construction Co. (sand and gravel, crushed rock)	52-53	1500 W. Seventh St., Long Beach	El Modena
Placer County:			
Joe Chevreaux (sand and gravel)	52-53	P.O. Box 65, Sta. A, Auburn	Auburn
Union Granite Co., Ruhkala Bros. (crushed rock—macadam, ballast, rubble, riprap, etc.)	52-53	P.O. Box 819, Rocklin	Rocklin
Plumas County:			
Western Pacific Railroad Co. (crushed rock)	52-53	526 Mission St., San Francisco 5	Tobin
Riverside County:			
A. T. & S. F. Ry. Co. (ballast)	52-53	121 E. Sixth St., Los Angeles 14	Box Springs
Guy F. Atkinson Co. (rubble, riprap)	52-53	P.O. Box 259, Long Beach	Bly Junction
Brolin Sand & Gravel (sand and gravel)	52	Thermal	Thermal
Desert Rock Co. (sand and gravel)	52-53	P.O. Box 1065, Indio	Palm Springs
Haven Granite Corp. (poultry grit)	53	890 S. Arroyo Parkway, Pasadena	Riverside
Emil Johnson (crushed rock—macadam)	52-53	Rt. 2, Box 185, Escondido	Perris
Massey Rock & Sand Co. (sand and gravel)	52-53	Box 1065, Indio	Indio
Miller Bros. Truck Co. (molding sand)	53	3451 Randolph St., Huntington Park	Riverside
Owens-Illinois Glass Co. (glass sand)	52-53	350 Sansome St., San Francisco	Corona
Palm Springs Bldrs. Supply Co. (sand and gravel)	52-53	490 Sunny Dunes Rd., Palm Springs	Whitewater
San Gorgonio Rock Products (sand and gravel)	52-53	1990 N. Hargrove St., Banning	Banning
Service Rock Co. (sand and gravel)	52	Box 309, Riverside	Riverside
J. B. Stringfellow (crushed rock)	53	P.O. Box 6, Riverside	Riverside
Transit Mixed Concrete Co. (sand and gravel)	52	3464 E. Foothill Blvd., Pasadena	Corona
Valley Rock & Sand Corp. (sand and gravel)	52-53	Rt. 1, Box 198, San Jacinto	Moreno
Sacramento County:			
American River Sand & Gravel Co. (sand and gravel)	52-53	P.O. Box 156, Perkins	Perkins
Asta Construction Co. (sand)	53	P.O. Box 758, Rio Vista	Rio Vista
Brighton Sand and Gravel Co. (sand and gravel)	52-53	P.O. Box 1, Perkins	Perkins
Del Paso Rock Products Co. (sand and gravel)	52-53	3490 Fair Oaks Blvd., Sacramento	Del Paso
Fair Oaks Gravel Co. (sand and gravel)	52-53	4000 Illinois Ave., Fair Oaks 19	Fair Oaks
Haggin Gravel Co.	53	16th St. and American River, Sacramento	Sacramento
Hard Materials Co. (molding sand)	53	12th and American River, Sacramento	Sacramento
McGillivray Construction Co. (sand and gravel)	52-53	P.O. Box 873, Sacramento 4	Sacramento
Pacific Coast Aggregates, Inc. (sand, and gravel, crushed rock—macadam, ballast, rubble, riprap, etc.)	52-53	400 Alabama St., San Francisco	Fair Oaks, Prattrock and American River
Perkins Gravel Co. (sand and gravel)	52-53	1931 Stockton Blvd., Sacramento	Perkins
Robert Powell Products (sand)	53	632 37th St., Sacramento	Sacramento
J. R. Reeves (sand and gravel, crushed rock—macadam, ballast, etc.)	52	P.O. Box 1072, Sacramento	Sacramento
Robertson Sand & Gravel Co. (sand and gravel)	53	1061 Vine St., Sacramento	Sacramento
A. Teichert & Son, Inc. (sand and gravel)	53	P.O. Box 928, Sacramento 4	Perkins
San Benito County:			
Granite Rock Co. (crushed rock—macadam, ballast)	52-53	Box 151, Watsonville	Logan

Sand, Gravel, and Stone, Miscellaneous—Continued

Operator	Years	Address	Location
San Bernardino County:			
Brubaker-Mann Co. (roofing granules)	52-53	Star Rt. 1-A, Barstow	Barstow
Consolidated Rock Products Co. (sand and gravel, crushed rock—macadam, ballast, rubble, riprap, etc.)	52-53	2730 S. Alameda St., Los Angeles	Claremont
Fontana Gravel Co. (sand and gravel)	52-53	P.O. Box 157, Fontana	Fontana
Fourth St. Rock Crusher (sand and gravel)	52-53	P.O. Box 469, San Bernardino	San Bernardino
Geo. Herz & Co. (sand and gravel)	52-53	P.O. Box 191, San Bernardino	San Bernardino
Holliday Rock Co. (sand and gravel)	52-53	P.O. Box 215, Upland	Upland and Colton
Rainbow Rock, Inc. (roofing granules)	53	P.O. Box 306, Barstow	Barstow
Redlands Gravel Co. (sand and gravel)	52-53	305 S. Buena Vista St., Redlands	Redlands
San Bernardino Rock & Gravel Co. (sand and gravel)	52-53	1910 W. Seventh St., San Bernardino	San Bernardino
Service Rock Co. (sand and gravel)	53	P.O. Box 309, Riverside	Colton
Sharp-Fellows Construction Co. (crushed rock)	52-53	533 Central Bldg., Los Angeles	Newberry
Triangle Rock & Gravel Co. (sand and gravel)	52-53	P.O. Box 2098, San Bernardino	San Bernardino
Tri-City Rock Co. (sand and gravel)	52-53	P.O. Box 789, Redlands	Redlands
Union Pacific Railroad Co. (sand and gravel—railroad ballast)	52-53	1416 Dodge St., Omaha 2, Neb.	Baxter
San Diego County:			
American Sand Co. (molding sand, blast sand)	52-53	P.O. Box 5326, San Diego 5	San Diego
Charles & Victor Arnell, Lakeside Sand Plant (sand and gravel)	52-53	Rt. 1, Box 10, Lakeside	Lakeside
Canyon Rock Co. (sand and gravel, crushed rock)	52-53	Box F, Hillcrest Sta., San Diego 3	San Diego
Caudell & Johnson (sand and gravel)	52-53	Box B, Hillcrest Sta., San Diego 3	Mission Valley, Poway Valley
Crystal Silica Co. (sand and gravel, filter sand)	52-53	717 E. 61st St., Los Angeles 1	Oceanside
Daley Corp. (sand and gravel)	52-53	Mission Valley & Ward Rd., San Diego 4	San Diego
Denton's Sand Plant, Edmond Denton (sand and gravel)	52-53	4166 Pelper Dr., San Diego 5	El Cajon
Escondido Sand & Gravel Co. (sand and gravel)	52-53	440 N. Tulip St., Escondido	Escondido
H. G. Fenton Material Co., Inc. (sand and gravel)	52-53	1245 National Ave., San Diego 12	San Diego
Mrs. Henry Gray (sand and gravel)	52-53	609 S. Hill St., Oceanside	Oceanside
C. R. Guthridge Sand Plant (sand)	52-53	7660 Girard Ave., La Jolla	Del Mar
Monarch Materials Co. (sand and gravel)	52-53	P.O. Box 81, Santee	Santee
Nelson & Sloan (sand and gravel)	52-53	Box 488, Chula Vista	Chula Vista
Carl Niemann (sand and gravel)	52-53	Box 52, Del Mar	Rancho Santa Fe
H. W. Rohl Co., Inc. (sand and gravel)	52-53	P.O. Box 28, Oceanside	Oceanside
Valley Granite Co. (riprap)	52	243 E. Fifth St., Escondido	Escondido
Vista Cement Products, A. J. McFall (sand and gravel)	52-53	156 W. Vista Way, Vista	Vista
Wiley Bros. (sand and gravel)	52-53	Rt. 1, Box 151, Fallbrook	Vista
Woodward Sand Co., Arthur C. Woodward (sand and gravel)	52-53	2914 Bancroft St., San Diego 4	San Diego
San Joaquin County:			
Beck Dredging Co. (sand)	53	305 Parrott Dr., San Mateo	Tracy
Neil Ellsbury, Mokelumne Pit (sand and gravel)	53	Clements	Clements
Pacific Coast Aggregates, Inc. (sand and gravel, crushed rock)	52-53	400 Alabama St., San Francisco	Riverbank, Tracy, Kerlinger

Putnam Sand & Gravel Co. (sand and gravel)	52-53	P.O. Box 486, Modesto	Riverbank
P. F. Sievers, Mokelumne Pit (sand and gravel)	52	P.O. Box 24, Clements	Clements
Tracy Rock & Gravel Co. (sand and gravel)	52-53	P.O. Box 307, Stockton	Tracy
Claude C. Wood Co. (sand and gravel)	52-53	P.O. Box 599, Lodi	Clements
San Luis Obispo County:			
Guiton Molding Sand Co. (sand and molding sand)	52-53	Box 515, Oceano	Oceano
Walter B. Roselip (sand and gravel)	52-53	Box 251, San Luis Obispo	Atascadero
San Mateo County:			
California Aggregates (crushed rock)	52-53	185 Bayshore Blvd., San Francisco	Rockaway Beach
Pacific Coast Aggregates, Inc. (crushed rock and sand)	52-53	400 Alabama St., San Francisco	Brisbane and Junipero Serra Blvd.
Rockaway Quarry, Inc. (sand)	52-53	340 Pine St., San Francisco	Rockaway Beach
Skyline Quarries (crushed rock)	52-53	P.O. Box 278, Belmont	Belmont
Peter Sorenson (crushed rock—macadam, fill rock)	52-53	927 Arguello, Redwood City	Belmont
Santa Barbara County:			
Buell Flat Rock (sand and gravel)	52-53	Solvang	Solvang
Southern Pacific Milling Co. (sand and gravel)	52-53	735 State St., Santa Barbara	Santa Maria
Valley Rock & Sand Co. (sand and gravel)	52-53	218 S. "L" St., Lompoc	Santa Ynez
Santa Clara County:			
J. C. Bateman, Inc. (fill rock)	53	650 Stockton Ave., San Jose	San Jose
Los Gatos Construction Co. (gravel)	52-53	P.O. Box 111, Los Gatos	Los Gatos
Los Gatos Sand and Gravel Co. (sand and gravel)	52-53	P.O. Box 502, Los Gatos	Los Gatos
Mirassou Bros. (crushed rock)	53	15630 Harwood Rd., Los Gatos	Los Gatos
Leo F. Piazza Paving Co. (sand and gravel)	52-53	Rt. 1, Box 800, San Jose	San Jose
A. J. Raisch Paving Co. (sand and gravel)	52-53	900 W. San Carlos St., San Jose	San Jose
Sondgrath Bros. (crushed rock)	52-53	146 Sierra Vista Ave., Mountain View	Los Altos
A. Voss (sand and gravel)	52-53	10445 Stevens Rd., Cupertino	Stevens Creek
Western Gravel Corp. (sand and gravel)	52-53	P.O. Box 1026, Campbell	Campbell
Western Tile & Supply Co. (sand and gravel)	52-53	P.O. Box 104, Gilroy	Gilroy
Santa Cruz County:			
Hansen, Silvey, & Sinnott (gravel)	52-53	P.O. Box 357, Felton	Felton
Henry J. Kaiser Co. (sand)	52-53	1924 Broadway, Oakland	Olympia
V. W. Maddock (sand and gravel)	53	P.O. Box 177, Soquel	Soquel
Pacific Coast Aggregates, Inc. (sand and gravel, crushed rock)	52-53	400 Alabama St., San Francisco	Olympia
Santa Cruz Aggregate Co. (sand and gravel)	52-53	646 Lockhart Gulch Rd., Santa Cruz	Felton and Olympia
Shasta County:			
Fredrickson & Watson Construction Co. (sand and gravel)	53	873 81st St., Oakland	Anderson
J. H. Hein Co. (sand and gravel)	52-53	P.O. Box 226, Redding	Redding
Oaks Sand, Gravel & Cement Products Co. (sand and gravel, crushed rock)	52-53	1737 Yuba St., Redding	Redding
Bert C. Peeler (sand and gravel)	52-53	P.O. Box 93, McArthur	Fall River Mills
Siskiyou County:			
John S. Jensen & M. N. Thompson (sand and gravel)	52-53	Box 836, Mount Shasta	Mount Shasta
Southern Pacific R.R. Co., Chief Engineer (slag and volcanic cinder)	52	Southern Pacific Bldg., San Francisco	Kegg

Sand, Gravel, and Stone, Miscellaneous—Continued

Operator	Years	Address	Location
Solano County:			
Fredrickson Bros. (crushed rock, fill rock)	52-53	1259 65th St., Emeryville	
J. M. Nelson, Cordelia Quarry (crushed rock—macadam, riprap)	52-53	Rt. 1, Cordelia	Cordelia
Parish Bros. (crushed rock—macadam, riprap)	52-53	Benicia	Benicia
Sonoma County:			
Basalt Rock Co. (sand and gravel, crushed rock, riprap, etc.)	52-53	P.O. Box 5401, Eighth and River Sts., Napa	Healdsburg
S. Cabrol (flagstone)	52	Rt. 1, Box 115, Glen Ellen	Glen Ellen
Construction Supply Co. (crushed rock)	53	1330 King St., Santa Rosa	Santa Rosa
Gordenker Bros. (flagstone)	52	R.F.D. Box 112a, Glen Ellen	Glen Ellen
Thomas A. Graham (crushed rock—macadam)	52-53	Box 1, Occidental	Occidental
Hein Bros. Basalt Rock Co., Mark Hein, Pres. (crushed rock—macadam, ballast)	52-53	P.O. Box 162, Petaluma	Petaluma
Maxwell Bros. (sand and gravel)	52-53	1330 King St., Santa Rosa	Santa Rosa
Talbert Rock Quarry (crushed stone)	52-53	P. O. Box 92, Cotati	Cotati
L. T. Willig (sand and gravel)	52-53	Jenner	Jenner
Stanislaus County:			
American Sand & Gravel Co. (sand and gravel)	53	Ninth and M Sts., Modesto	Empire
Gallager & Burk, Inc. (sand and gravel)	52	344 High St., Oakland	Millsmont
Graystone Tile (sand and gravel)	52-53	316 River Rd., Modesto	Modesto
Hughson Gravel Plant (sand and gravel)	52-53	P.O. Box 35, Hughson	Hughson
Frank B. Marks & Sons (sand and gravel)	52-53	P.O. Box 668, Newman	Newman
Modesto Sand and Gravel Co., Inc. (sand and gravel)	52-53	Rt. 2, Box 901R, Modesto	Modesto
Putnam Sand & Gravel Co. (sand and gravel)	53	P.O. Box 486, Modesto	Modesto
Santa Fe Rock & Sand Co. (sand and gravel)	52-53	Rt. 6, Box 1419, Modesto	Waterford
Standard Rock Co. (sand and gravel)	53	P.O. Box 246, Escalon	Escalon
Chas. D. Warner & Son, Inc. (sand and gravel)	52-53	1027 Yosemite Blvd., Modesto	Modesto
Sutter County:			
Lester Rice & Sons (sand and gravel)	53	Yuba City	Yuba City
Tehama County:			
Allen, Hulseman & Paulsen (sand and gravel)	53	P.O. Box 729, Red Bluff	Red Bluff
Allen & Reddy (sand and gravel)	52	Box 729, Red Bluff	Red Bluff
Fredrickson & Watson Construction Co. (sand and gravel)	53	837 81st St., Oakland	Red Bluff
Trinity County:			
Northwestern Pacific R.R. Co. (crushed rock, ballast)	52-53	San Rafael	Island Mountain
Trinity Sand & Gravel Co. (sand and gravel)	53	Weaverville	Douglas City
Tulare County:			
Middletons-Sequoia Rock Co. (sand and gravel)	52-53	P.O. Box 1468, Visalia	Porterville

Pacific Coast Aggregates, Inc. (sand and gravel, crushed rock)	52-53	400 Alabama St., San Francisco	Lindsay and Lemon Cove
Terminus Beach Rock Co. (sand and gravel)	52	P.O. Box 291, Lemon Cove	Lemon Cove
Tuolumne County:			
Beerman & Jones (sand and gravel, riprap)	52-53	P.O. Box 698, Sonora	Soulsbyville
Ventura County:			
Miller Bros. Truck Co. (molding sand)	52-53	3451 Randolpy St., Huntington Park	Ventura
Montalvo Rock Co. (sand and gravel)	52-53	Box 188, Montalvo	Montalvo
Santa Paula Rock Co. (sand and gravel)	52	P.O. Box 671, Santa Paula	Santa Pauia
Saticoy Rock Co. (sand and gravel, crushed rock—macadam)	52-53	Box 970, Ventura	Saticoy-Ventura
Southern Pacific Milling Co., Santa Paula Rock Div. (sand and gravel)	52-53	P.O. Box 671, Santa Paula	Santa Paula
Yolo County:			
Madison Sand & Gravel Co. (sand and gravel)	52-53	P.O. Box 66, Madison	Madison
Pacific Coast Aggregates, Inc. (sand and gravel)	52-53	400 Alabama St., San Francisco	Yolo
W. C. Railing (sand and gravel)	52-53	P.O. Box 651, Woodland	Woodland
Schwarzgruber & Sons (sand and gravel)	52-53	28 W. Main St., Woodland	Cache Creek
Mrs. Lucy L. Woods (sand and gravel)	52	915 First St., Woodland	Woodland
Yuba County:			
Rice Bros. (sand and gravel)	52-53	P.O. Box 1489, Marysville	Marysville
Yuba River Sand Co. (sand and gravel)	52-53	Box 307, Marysville	Marysville

Silica

Operator	Years	Address	Location
Kern County:			
N. W. Sweetser (quartz)	52-53	Box 445, Rosamond	Rosamond
Mariposa County:			
Kaiser Aluminum & Chemical Corp. (quartz)	52-53	Permanente	Le Grande
Monterey County:			
Del Monte Properties (ground silica sand)	52-53	P.O. Box 150, Pacific Grove	Pacific Grove
Owens-Illinois Glass Co. (glass sand)	52-53	350 Sansome St., San Francisco 19	Pacific Grove
Riverside County:			
Owens-Illinois Glass Co. (glass sand)	52-53	350 Sansome St., San Francisco 19	Corona
San Bernardino County:			
Mineral Materials Co., (quartzite) C. W. Dunton, Mgr.	52-53	1145 Westminster Ave., Alhambra	Oro Grande
Riverside Cement Co., (quartzite)	52-53	621 S. Hope St., Los Angeles 17	Oro Grande

Slate

Operator	Years	Address	Location
El Dorado County:			
Kelsey Slate Co., Bill Powell (flagstone)	52-53	Box F, Kelsey	Kelsey
Pacific Minerals Co., Ltd., (granules, filler)	52-53	337 10th St., Richmond	Chili Bar

Soda

Operator	Years	Address	Location
Inyo County:			
Natural Soda Products Co. (soda ash, trona)	52	405 Montgomery St., San Francisco 4	Keeler
Pittsburgh Plate Glass Co., Columbia Chemical Division (soda ash, trona)	52-53	Bartlett	Bartlett
San Bernardino County:			
American Potash & Chemical Co. (soda ash, salt cake)	52-53	3030 W. Sixth St., Los Angeles 54	Trona
West End Chemical Co., (soda ash)	52-53	608 Latham Sq. Bldg., Oakland 12	Westend

Strontium Minerals

Operator	Years	Address	Location
Imperial County:			
Pan Chemical Co.	53	3461 E. 26th St., Los Angeles	Brawley

Sulfur

Operator	Years	Address	Location
Alpine County:			
Anaconda Copper Mining Co.	53	25 Broadway, New York 4, N. Y.	Markleeville
Inyo County:			
Inyo Soil Sulfur Co.	52-53	310 Pacific St., Bakersfield	Last Chance Mts.
Mrs. Gertrude L. Ott	52	P.O. Box 651, Big Pine	Last Chance Mts.

Talc, Soapstone and Pyrophyllite

Mine	Operator	Years	Address	Location
El Dorado County:				
(soapstone)	Pacific Minerals Co., Ltd.	52-53	337—10th St., Richmond	Shingle Springs
Inyo County:				
Longhorn (talc)	W. H. Anderson	52-53	Box 733, Bigpine	Bigpine
Eureka (talc)	F. A. Bachich	53	P.O. Box 658, Bigpine	Bigpine
Alberta, Florence, and White Mt. (talc)	Wm. Bonham	53	P.O. Box 446, Lone Pine	Keeler
Big Talc and Warm Springs (talc)	Louise Grantham et al.	52-53	237 N. 2d St., Upland	Bigpine
Eureka (talc)	Ray Harlis	52-53	Bigpine	Bigpine
White Eagle (talc)	Huntley Industrial Minerals Inc.	53	P.O. Box 305, Bishop	Bigpine
Alliance & Silver Dollar (talc)	George W. Koest	52-53	P.O. Box 85, Darwin	Darwin
Eclipse (talc)	Kennedy Minerals Co., Inc.	52-53	2552 E. Olympic Blvd., Los Angeles 23	Bigpine
Death Valley (talc)	Multi Mines, Inc.	52-53	2550 E. Olympic Blvd., Los Angeles 23	Shoshone
Eclipse (talc)	A. E. Nicholls	52	Darwin	Darwin
Eureka (talc)	James F. Nikolaus	52	109 S. Main, Bigpine	Bigpine
Gray Eagle (talc)	G. P. Rogers	52-53	Box 39, Big Pine	Bigpine
(Frisco, Talc City, Trinity, Panamint, Tecopa (talc) Saline, Ubehebe)	Sierra Talc & Clay Co.	52-53	1608 Huntington Dr., South Pasadena	Keeler, Shoshone and Tecopa
Los Angeles County:				
Dr. Katz (soapstone)	Dr. Leon N. Katz	52-53	9837 Foothill Blvd., San Fernando	Acton
Mono County:				
Pacific (pyrophyllite)	Huntley Industrial Minerals, Inc.	52-53	P.O. Box 305, Bishop	Laws
Riverside County:				
H. & K. (pyrophyllite)	E. T. Hermann & Geo. Keller	53	Box B, Thermal	Desert Center
San Bernardino County:				
Desert Talc and Yucca Grove (talc)	Desert Talc & Clay Co.	52-53	629 N. La Brea Ave., Los Angeles 36	Yucca Grove
Victor (pyrophyllite)	Mineral Materials Co., Ltd.	52-53	1145 Westminister Ave., Alhambra	Victorville
Monarch (talc)	Ralph Morris & Associates	53	R. 804—612 S. Flower St., Los Angeles 17	Shoshone
Saratoga (talc)	Saratoga Talc Co.	53	P.O. Box 74, Baker	Baker
Monarch Sheep Creek, and Silver Lake (talc)	Sierra Talc & Clay Co.	52-53	1608 Huntington Dr., South Pasadena	Shoshone and Baker
Calmasil, Excelsior, and Superior (talc)	Southern California Minerals Co.	52-53	320 S. Mission Rd., Los Angeles 33	Ivanpah, Shoshone and Baker
W. S. Skeoch (talc)	Western Talc Co.	52-53	1901 E. Slauson Ave., Los Angeles	Tecopa
San Diego County:				
Mathews (pyrophyllite)	Pioneer Pyrophyllite Products	52	P.O. Box 686, Chula Vista	Del Mar

Wollastonite

Operator	Years	Address	Location
Riverside County:			
Western Development Co., c/o Maurice Willows Jr.	52	218 N. Canon Dr., Beverly Hills	Midland

Antimony

Mine	Operator	Years	Address	Location
Kern County:				
Big Oscar	*Abaca Mining Co.		P.O. Box 293, Inyokern	Inyokern

* Mined in 1953 but made no shipments.

Chromite

Mine	Years	Operator	Address	Location
Alameda County:				
Mendenhall & Newman	53	Palo Alto Mining Corp.	521 S. San Tomas Rd., Campbell	Livermore
Butte County:				
Lambert	52-53	Helmke, Thomas and Janssen	320 Market St., San Francisco	Magalia
Majestic	53	V. R. McNichols	Rt. 5, Box 2045-C, Oroville	
Del Norte County:				
Bar-Rick, Blue Bird, High Point, & Skyline	53	Ernest Tarball	P.O. Box 85, Cave Junction, Oregon	High Plateau
Buckskin-Fourth of July	52-53	C. H. McClendon	P.O. Box 61, Crescent City	Crescent City
Chrome Hill	52-53	Peter Janzen	c/o Symons Camp, Gasquet	Patrick Creek
Coon Creek	53	Pioneer Mining Co.	Gasquet	
Eagles Nest	53	George Shicora & Stan Planchon	P.O. Box 803, Crescent City	Smith River
Elk Camp	53	Carl Verstagn & Melvin Eaton	416 E. "A" St., Grants Pass, Oregon	Smith River
Elk Creek	52	L. J. Harper	Patrick Creek Inn, via O'Brien, Oregon	Patrick Creek
French Hill	52-53	J & W Mining Co.	Box 332, Gasquet	Gasquet
Higgins Brass	52-53	Ted Webb	P O. Box 32, O'Brien, Oregon	Patrick Creek
High Plateau	52-53	E. R. Brown	O'Brien, Oregon	High Plateau

Holliday	52	Holliday Mines, Inc.	Box 509, Crescent City	Gasquet
Holliday	53	Ashland Mining Co.	835 N. Main St., Ashland, Oregon	Gasquet
Holliday (High Dome)	53	Tulare Bros.	P.O. Box 509, Crescent City	Gasquet
Hollywood	53	Tom Cronin	Crescent City	Low Divide
Judy	52	James L. Perry	c/o Carl Spieth, Rt. 1, Box 884, Cave Junction, Oregon	Patrick Creek
Mountain View	52-53	Tyson Mining Co.	P.O. Box 191, Smith River	Smith River
Old Doe	53	Harold Funk	Rt. 1, Box 782, Crescent City	Low Divide
Paday No. 8	53	R. F. Reuss	Box 72, Smith River	Smith River
Sensation	53	Jim Graham	1918 Nebraska Ave., Grants Pass, Ore.	Gordon Mt.
Sunrise	53	Nealy Logging Co.	Kerby, Oregon	Gasquet
El Dorado County:				
Cornelius Pty.	53	El Dorado Chrome Co.	El Dorado	Latrove
Forest Hill	53	Ashland Mining Co.	835 N. Main St., Ashland, Oregon	-----
Little Bald Mtn.	53	Lunium Company (J. A. Hoppe)	Rt. 1, Box 1074, Auburn	Georgetown
Pilliken	52-53	Allied Mining Co.	Box D, Lincoln	Rattlesnake
Pilliken	53	Lawerence Skickling	P.O. Box 907, Auburn	Rattlesnake
Fresno County:				
Jones-Thickstum	52	West Coast Chrome Producers	P.O. Box 324, Coalinga	Coalinga
Mistake	53	J. R. Holman	1465 E. Orange Grove Ave., Pasadena	Coalinga
Glenn County:				
Chrome King	53	Anderson Bros	208 Gross Ave., Marysville	Stonyford
Lake County:				
Ellis Ranch, Flanders & Mirabel	53	James I. Scott	P.O. Box 516, Middletown	Lower Lake and Middletown
Napa County:				
Chrome Dome	53	James I. Scott	P.O. Box 516, Middletown	Middletown
White Angel	53	Lunium Co. (Jack A. Hoppe)	Rt. 1, Box 1074, Auburn	Knoxville
Placer County:				
Baker Ranch	53	L. L. Anderson	Forest Hill	Forest Hill
Bear Wallow	52	Joseph Delume	Box 72, Forest Hill	Forest Hill
Sunset	53	C. L. Matthews	Iowa Hill	Iowa Hill
Twin Shafts	52-53	John Mehl & Ray A. Graetz	Forest Hill	Forest Hill
San Luis Obispo County:				
Castro	53	Castro Mining Co.	625 Market St., San Francisco	Goldtree
Hard Face & London	52-53	Pierce Bros.	P.O. Box 386, Morro Bay	Morro Bay
London	53	H. J. Stevens	Cayucos	Goldtree
Pick & Shovel	53	Harold Biaggini & W. D. Pierce	Box 379, Cayucos	Chorro Creek
Seeley-Miller property	53	San Luis Mining Co.	1185 Monterey St., San Luis Obispo	Chorro Creek
Sweetwater	53	Ruda & Negranti	Cayucos	Goldtree
Sweetwater & Norcross	52-53	H-J Chrome Co.	San Luis Obispo	Goldtree
Sweetwater & Norcross	52	International Metallurgical Chrome Corp.	1026 Chorro St., San Luis Obispo	Goldtree

Chromite—Continued

Mine	Years	Operator	Address	Location
Santa Barbara County:				
Cachuma	52-53	Harry L. Roberts	Box 101, Los Olivos	Figueroa Mountains
Santa Clara County:				
O'Connell	53	Palo Alto Mining Co.	521 N. San Tomas Rd., Campbell	Edenvale
Shasta County:				
Brown & Costa Ranch	53	Ashland Mining Co.	835 N. Main St., Ashland, Oregon	La Moine
Forest Queen	52-53	W. A. Orsini	Box 181, Summit City	La Moine
Siskiyou County:				
Big Dipper & Lewis	53	Ashland Mining Co.	835 N. Main St., Ashland, Oregon	Seiad
Big Yank	53	Ira J. Smith & Kenneth Heap	P.O. Box 21, Grants Pass, Oregon	
Black Bear	52-53	L. J. Conley	1270 Orchard Home Dr., Medford, Oregon	Gazelle
Black Hawk	52	Francis George	Cecilville	Cecilville
Black Jack	52-53	D. W. Hatcher	Box 344, Yreka	Trail Gulch
Blue Eagle	52	S. H. & S. Mining Co.	626 S.W. Sixth St., Grants Pass, Oregon	Seiad
Cameron & Sappington	53	C. B. Sappington	1881 S.E. "N" St., Grants Pass, Oregon	Gazelle
Cyclone Gap	52-53	Ruth Robertson	Box 475, Grants Pass, Oregon	Preston Peak
Dry Gulch	52-53	W. R. George	Sawyers Bar	Cecilville
Gazelle Mountain	53	J. A. Richter	Box 297, Callahan	Gazelle
Masterson	53	J. T. Eastlick	P.O. Box 583, Fort Jones	Gazelle
Mountain View	53	Elmer T. Weeks	Seiad Valley	Seiad Valley
Opportunity	52	James I. Scott	P.O. Box 516, Middletown	Gazelle
Opportunity Grp.	53	Ray M. Sharples	1215 S. Main St., Yreka	Gazelle
Riverview	53	Pell Mining Co.	Hamburg	Hamburg
Roadside	53	J. L. Laek	Cottage Grove	Dillion Creek
Rough Mountain	53	Rough Mountain Mining Co.	Box 206, Yreka	Moffett Creek
Section 31	53	Henry L. Shuster	P.O. Box 825, Yreka	Gazelle
Seiad	53	Scotts Bar Mining Co.	Scotts Bar	Seiad
West Side & Brockway	53	L. R. Hatcher	P.O. Box 134, Yreka	Moffett Creek
	53	Carver Gepford	Box 81, Etna	Etna
	53	H. H. Hansen	Etna	Etna
	53	Fredrick Stone	Etna	Etna
Sonoma County:				
Morse Ranch	53	James I. Scott	P.O. Box 516, Middletown	Middletown
Tehama County:				
Blue Sky, Lucky Star, North Fork, & Seagraves	52-53	Tedoc Mining Co.	Platina	Platina
Cadillac	53	Jess Latin & Joseph Cerny	2164 Sonoma St., Redding	Beegum
Elder Creek	53	Elder Creek Mining Co.	2700 19th St., San Francisco	Elder Creek

Grau—State School Land	52-43	Conconully Mining & Milling Co.	Red Bluff	Kleinsorge
McArthur	53	Red Mountain Mining Co.		Tedoc
Star Group	53	Mark Hausman	P.O. Box 1391, Redding	Tedoc
Trinity County:				
Big Hunk & Little Nellie	53	George W. Patton	Box 585, Hayfork	Hayfork
Black Bear	53	Lowel Norgaar	Hayfork	Hayfork
Little Goat	52-53	Jess Latin & Joseph Cerny	2164 Sonoma St., Redding	Beegum
Mumbo	53	Floyd Munson	Box 315, Etna	Carrville
Mumbo	53	Eric Schoonmacher	Rt. 1, Box 356, Yreka	Carrville
Three B's	52	Brewer & Cherry	Big Bar	Big Bar

Copper

Principal copper producers in California in 1952 and 1953.
(Not less than 10,000 pounds per year.)

Mine	Years	Operator	Address	Location
Calaveras County:				
Penn	52	Penn Chemical Co., Inc.	Campo Seco	Campo Seco
Penn	53	New Penn Mines, Inc.	70 Pine St., New York 5, N. Y.	Campo Seco
El Dorado County:				
Noonday	53	Volo Mining Co.	P.O. Box 286, Placerville	Diamond Springs
Inyo County:				
Darwin Group	52-53	Anaconda Copper Mining Co.	25 Broadway, New York, N. Y.	Darwin
Pine Creek	52-53	U.S. Vanadium Co.	30 E. 42d St., New York, N. Y.	Bishop
Shoshone Group	52	Anaconda Copper Mining Co.	25 Broadway, New York, N. Y.	Tecopa
Madera County:				
Jesse Bell	52-53	H. J. Buchenau	Star Rt., Box 17, Madera	Daulton Station
San Bernardino County:				
Bagdad-Chase	52-53	Donald F. Love	Box D, Ludlow	Ludlow
Hoffman Estate (Bagdad-Chase tailings)	52-53	Pacific Coast Mill & Mining Co.	1020 Highland Ave., National City	Ludlow
Virginia May & Horn	52-53	Turtle Mountain Mining Co.	P.O. Box 547, Earp	Earp
Shasta County:				
Afterthought	52	Coronado Copper & Zinc Co.	1206 Pacific Mutual Bldg., Los Angeles	Bella Vista
Hornet-Richmond	52-53	Mountain Copper Co., Ltd.	230 California St., San Francisco	Matheson
Kennett Smelter Cleanings	52	International Smelting & Refining Co.	818 Kearns Bldg., Salt Lake City, Utah	Coram

Gold

Principal gold producers in California in 1952-53. (Less than 100 oz. per year not listed.)

Mine	Years	Type of Mine*	Operator	Address	Location
Amador County:					
Lorentz group	52-53	h	Lorentz and Swingle	Plymouth	Plymouth
Old Eureka	52-53	a	Central Eureka Mining Co.	Box 880, San Jose	Sutter Creek
Butte County:					
Butte unit	52	f	Yuba Consolidated Gold Fields	351 California St., San Francisco	Biggs
Dredge No. 3	52	h	Thurman and Wright	625 Market St., San Francisco 5	Chico
Calaveras County:					
Altaville (Alta)		u	Gold Bar Mining Co.	Box 10, Altaville	Altaville
Blackstone		a	Blackstone Mine	5208 Barrett Ave., Richmond	West Point
McCarty	52-53	h	Mountain Gold Dredging Co.	Sutter Creek	Valley Springs
Penn	52	l	Penn Chemical Co., Inc.	Campo Seco	Campo Seco
Tobia Granitta Ranch	52	h	Mid-State Dredging Co.	Douglas Flat	Douglas Flat
El Dorado County:					
Hazel Creek	52-53	a	Hazel Creek Mining Corp.	P.O. Box 309, Placerville	Sly Park
Fresno County:					
Rockfield	52-53	s	Pacific Coast Aggregates, Inc.	400 Alabama St., San Francisco	Friant
Imperial County:					
Cargo Muchacho	52	a	Holmestake Mining Co.	Box 308, Winterhaven	Ogilby
Inyo County:					
Darwin Group	52-53	m,d	Anaconda Copper Mining Co.	25 Broadway, New York, N. Y.	Darwin
Kern County:					
Butte Lode	52	a	Butte Lode Mining Co.	P.O. Box 195, Randsburg	Randsburg
Cactus Queen	52-53	a	Burton Mines, Inc.	Rosamond	Mojave
Fox gravel	52	s	Hartman Concrete Material Co.	Box 1632, Bakersfield	Kern River
Golden Queen	52	a	N. W. Sweetser	P.O. Box 445, Rosamond	Mojave
Standard	52	a	E. B. Blickenstaff	Mojave	Mojave
Tropico	52-53	a	Burton Bros., Inc.	Rosamond	Willow Spring
Whitmore	52	c	Red Ink Mining Co.	7214 Sepulveda Blvd., Van Nuys	Mojave
Yellow Aster	52-53	a	King Solomon lease	Box 101, Johannesburg	Randsburg
Los Angeles County:					
Azusa Rock & Sand Co.	53	s	San Gabriel Valley Placers	1237 S. Greenwood Ave., Montebello	Montebello

Madera County:					
Jesse Bell	53	r	H. J. Buchenau	Star Rt. Box 17, Madera	Daulton Station
Mariposa County:					
Horse Shoe	53	a	Horse Shoe Mine & Seaview Lumber Co.	Box 21-B, Cazadero	Coulterville
Merced County:					
Marble Springs	52	a	Glenn Company	3134 E. Tenth St., Oakland	Coulterville
Snelling dredge	52	f	Snelling Gold Dredging Co.	Snelling	Snelling
Waltz property	53	j	Adobe Mining Co.	Rt. 4, Box 349, Madera	Hunter Valley
Mono County:					
Serita	53	a	Valley View Mines Co.	Box 763, Bridgeport	Bridgeport
Nevada County:					
Brunswick-Idaho Maryland	52-53	a	Idaho Maryland Mines Corp.	Grass Valley	Grass Valley
Eastman (Middle Fork)	52-53	i	Crescent Pacific Mining Co.	260 California St., San Francisco	North Bloomfield
Empire Star group	52-53	a	Empire Star Mines Co., Ltd.	Grass Valley	Grass Valley
Red Ledge	53	a	Redledge Mines	4704 69th St.. Sacramento	Washington
St. Louis Tunnel	53	a	Willow Valley Mines, Inc.	461 Market St., San Francisco	Nevada City
Willow Valley	52	a	Willow Valley Mines, Inc.	461 Market St., San Francisco	Nevada City
Placer County:					
Paragon	52	g	W. E. Wilson	P.O. Box 215, Forest Hill	Forest Hill
Sacramento County:					
Capital dredge	52	f	Capital Dredging Co.	351 California St., San Francisco	Folsom
Haggin Sand & Gravel Co.	52-53	s	Mrs. C. W. Craig	2457 Portola Way, Sacramento	Brighton
Natomas	52-53	f	Natomas Co., et al	Box 1197, Sacramento	Folsom
San Bernardino County:					
Bagdad-Chase	52-53	r	Donald F. Love	Box D, Ludlow	Ludlow
Hoffman Estate	52-53	d	Pacific Coast Mill & Mining Co.	1020 Highland Ave., National City	Ludlow
Rambler-Hilltop	52-53	a	Frank Czerwonka	Box 121, Lucerne Valley	Lucerne Valley
Telegraph	53	a	Dick Bright	Independence	Baker
Shasta County:					
Afterthought	52	l	Coronado Copper & Zinc Co.	1206 Pacific Mutual Bldg., Los Angeles	Bella Vista
Kennett smelter cleanings	52	v	International Smelting and Refining Co.	818 Kearns Bldg., Salt Lake City, Utah	Coram
Sierra County:					
Brush Creek	52-53	a	Best Mines Company	Box 177, Downieville	Goodyear Bar
Colombo	53	a	R. C. Hanford	Sierra City	Sierra City
Ireland	52	a	George Hyland	Alleghany	Allehgany
Kate Hardy	52	a	John O'Donnell	Alleghany	Alleghany
Kate Hardy	53	a	Harold H. Hawn	Box 748, Grass Valley	Alleghany
Oricke	53	g	Sierra Mining & Development Co.	La Porte	La Porte
Oriental	52-53	a	Dickey Exploration Co.	Alleghany	Alleghany
Original Sixteen to One	52-53	a	Original Sixteen to One Mine, Inc.	235 Montgomery St., San Francisco	Alleghany
Red Star (Yellow Jacket)	52-53	a	Yellow Jacket Consolidated Gold Mines	120 Chester Ave., Bakersfield	Alleghany

Gold—Continued

Mine	Years	Type of Mine*	Operator	Address	Location
Siskiyou County:					
Siskon	53	a	Siskon Corp.	Box 148, Happy Camp	Happy Camp
Trinity County:					
Bennett	52	g	Bennett Mining Co.	Big Bar	Big Bar
Fairview Placers	52-53	f	Fairview Placers	Lewiston	Minersville
Yuba County:					
Browns Valley group	52-53	a	Empire Star Mines Co., Ltd.	Grass Valley	Browns Valley
Yuba unit	52-53	f	Yuba Consolidated Gold Fields	351 California St., San Francisco 4	Hammonton

* LEGEND

a—lode gold mine
c—gold-silver mine
d—tailings dump
f—dredge (bucket-line)
g—hydraulic mine
h—dragline

i—dryland dredge
j—suction dredge
k—lead mine
l—zinc mine
m—zinc-lead mine
r—copper mine

s—commercial gravel plant
u—drift mine
v—flue dust and slag
w—drywashing

Iron

Mine	Years	Operator	Address	Location
Riverside County:				
Eagle Mountain	52-53	Kaiser Co., Inc.	Box 217, Fontana	Desert Center
San Bernardino County:				
Cave Canyon	52	California Portland Cement Co.	612 S. Flower St., Los Angeles 17	Amboy
Iron Age	52	Iron Mining Co., Edw. Hedstrom (to May 6, 1952)	544 Merritt Ave., Oakland	Amboy
Iron Age	52-53	Iron Age Mines Co., R. W. Jerome (from May 6, 1952)	3908 Glenridge Ave., Van Nuys	Amboy
Vulcan	53	Mineral Materials Co.	1145 Westminster Ave., Alhambra	Kelso
Shasta County:				
Shasta	53	Carrico & Gautier	365 Ocean Ave., San Francisco	Heroult

Lead

Principal lead producers in California in 1952 and 1953.
(Not less than 10,000 pounds per year)

Mine	Years	Operator	Address	Location
Calaveras County:				
Penn	52	Penn Chemical Co., Inc.	Campo Seco	Campo Seco
El Dorado County:				
Hazel Creek	52-53	Hazel Creek Mining Corp.	P.O. Box 209, Placerville	Sly Park
Inyo County:				
Big Four	52	Wooly J. Lorenz	Box 346, Lone Pine	Lone Pine
Darwin Group (tailings) & Defense	53	L. D. Foreman & Co.	1354 Second St., Salt Lake City, Utah	Darwin
Darwin (Lucky Jim) & Modoc dump	53	Sidney O. Gibbs	Box 48, Darwin	Darwin
Darwin group	52-53	Anaconda Copper Mining Co.	25 Broadway, New York, N. Y.	Darwin
Defense	52-53	L. D. Foreman & Co.	1354 Second Ave., Salt Lake City, Utah	Panamint Springs
Lane (tailings)	52	L. D. Foreman & Co.	1354 Second Ave., Salt Lake City, Utah	Keeler
Le Moigne	52-53	W. V. Skinner	625 Muir Ave., Lone Pine	Le Moigne
Minnetta	53	McFarland & Hullinger	23 Pinehurst Ave., Tooele, Utah	Panamint Springs
Ophir dump	52	Ned E. Raymond	Box 1071, Trona	Slate Range
Reward & Brown Monster	52-53	Reward Mining & Milling Corp.	14932 Delano, Van Nuys	Independence
Lippincott (Lead King)	52-53	Lippincott Lead Mines	Box 1811, Santa Ana	Scotty's Castle
Minnietta	52	Finley and Vignich	Panamint Springs via Lone Pine	Panamint Springs
Silver Bar	52	T. L. Bright	Independence	Independence
Silver Reid (Lee)	52-53	Albert Glenn & Ambrose Aquerreberry	Box 192, Darwin	Darwin
Stonewall	52	W. A. Fritz	Box 597, Trona	Slate Range
Shoshone group	52	Anaconda Copper Mining Co.	25 Broadway, New York, N. Y.	Tecopa
Ubehebe	52	Ubehebe Lead Mines, Inc.	R. 220, 356 S. Spring St., Los Angeles 12	Scotty's Castle
Mono County:				
Alexander (Green Monster)	52	Fowler Mining Corp.	Dyer, Nev.	White Mts.
San Bernardino County:				
Golden Witch	52	Golden Witch Mining Co.	Box 493, Colton	Barstow
War Eagle	52	Mining Development Co.	Rt. 1-B, Barstow	Barstow
Wilshire	52	W. Alexander & W. F. Fuel	114 Silver St., Henderson, Nev.	Clark Mountain
Shasta County:				
Afterthought	52	Coronado Copper & Zinc Co.	1206 Pacific Mutual Bldg., Los Angeles	Bella Vista
Kennett smelter cleanings	52	International Smelting and Refining Co.	818 Kearns Bldg., Salt Lake City, Utah	Coram

Manganese Ore

Mine	Years	Operator	Address	Location
Humboldt County:				
Fort Seward	53	Glenn E. Adkisson	Box 302, Redway	Fort Seward
Imperial County:				
Black Beauty	53	Walter D. Scott	136 N. Broadway, Blythe	Palo Verde
Lobo	53	M. E. Harter	Palo Verde	Palo Verde
Lobo	53	Kenneth O. Prouty	Palo Verde	Palo Verde
Lucky Boy	53	George Ringwald	Box 1111, Blythe	Blythe
Lugo & Tadpole	53	Roy Williams	P.O. Box 33, Ripley	Palo Verde
Mary Ellen	53	Charles L. Mills	Gen. Del., Palo Verde	Palo Verde
Pioneer	52-53	L. Mills Beam	10535 Buford Ave., Inglewood	Paymaster
Virginia Dare	53	Masciteli & Waters	Palo Verde	Palo Verde
Inyo County:				
Lilly	53	Roy Argo	11837 Loma Dr., Whittier	Sherman
Lucky Black	53	Charles B. Foster	169 Eureka St., San Francisco	Shoshone
Lake County:				
Grand View	53	Lang Bros. Sand & Gravel Co.	Lakeport	Lakeport
Last Chance	52	Consolidated Manganese Corp.	300 Montgomery St., San Francisco	
Mendocino County:				
Memorial & Rattlesnake	53	Herbert & Davis Filben	Ukiah	Foster Mountain and Ukiah
Plumas County:				
Arlington	52-53	F. A. Smith	c/o Greenville Inn, Greenville	Greenville
Indian Valley	52-53	O. H. Griggs	1903 Outpost Dr., Hollywood 28	Greenville
Mt. Hough	53	C. W. Hymer	Box 666, Quincy	Greenville
Mt. Hough	53	Terhal Farms, Inc.	P.O. Box 491, Colusa	Greenville
Sunset	53	Arlington Mines, Inc.	Almanor	Almanor
Riverside County:				
Arlington-Black Jack	52	Calrado Development Co.	Blythe	Ironwood
Arlington	53	A. B. Miner	Blythe	Ironwood
Arlington	53	A. T. Sweet & E. A. Brown	Gen. Del. Blythe	Ironwood
Arlington-Black Jack-Manganese Canyon	53	Dan Figueroa & Sons	Box 453, Blythe	Ironwood
Bertha	53	James F. George	Blythe	Ironwood

Black Ace	53	Ike W. Kusisto	P.O. Box 673, Wickenburg, Ariz.	Ironwood
Langdon	53	California Limestone Products	139 S. Beverly Dr., Beverly Hills	Ironwood
	53	Willis Loveless	Gen. Del., Las Vegas, Nev.	
	53	Chris G. Muller	Blythe	Blythe
San Benito County:				
Pacheco	53	E. Matthews & A. Pearde	Hollister	Stayton
San Bernardino County:				
B. & B.	53	James C. Gill	Box 22, Shoshone	Baker
Barnett-Monarch	53	Lelan Noblitt	Box 196, Parker, Ariz.	Whipple Mts.
Big Reef-van Dorn	53	Al Stovall	c/o L. H. Robertson, 1644 Palmcroft, Phoenix, Ariz.	Ludlow
Black Magic	53	P. & C. Development Co.	500 Macy St., Los Angeles 12	Owl Springs
Black Metal	53	Floyd Goodman	c/o Ranch House, Needles	Needles
Hill Top	53	Carl Noblitt	Cross Roads	Whipple Mts.
Manganese King	53	D. R. Harryman	Box 241, Parker, Ariz.	Whipple Mts.
Monarch	53	Roe T. Brook	Box 878, El Centro	Whipple Mts.
Monarch	53	Tom Noblitt	Gen. Del., Cross Roads	Whipple Mts.
Owl Springs	53	Robert A. Miller	182—E. 87 Place, Los Angeles	Owl Springs
Styer & Davenport	53	R. B. Styer & J. S. Davenport	Box 2363, Warren, Ariz.	Ludlow
	53	James Hovenkamp	106 E. 91st St., Los Angeles	
San Joaquin County:				
Ladd	52-53	Teekay Mines, Inc.	Box 245, Tracy	Tracy
San Luis Obispo County:				
Irish Hill & Silvester	53	R. W. Silvester & F. J. Vollmer	Box 681, San Luis Obispo	Santa Lucia
Trinity County:				
Blue Jay	52	Lincoln Gold Dredging Co.	1332 Willis St., Redding	Forest Glen
Blue Jay	53	K. P. F. & F. Mining Co.	1535 California St., Redding	Forest Glen
Stockton	52-53	Glenn E. Adkisson	Box 302, Redway	Fort Seward
Stockton & Manganese Queen	53	Ted Webb & Don Johnson	P.O. Box 283, Redding	Fort Seward
	53	Leslie L. Hodges	P.O. Box 504, Hayfork	Hayfork
Sonoma County:				
Boyer	53	Consolidated Manganese Corp.	300 Montgomery St., San Francisco	Geyserville

Mercury (Quicksilver)

Mine	Years	Operator	Address	Location
Contra Costa County:				
Mt. Diablo	52	Mt. Diablo Mine, Ronnie Smith, Trustee	2106 Tower Petroleum Bldg., Dallas, Tex.	Clayton
Del Norte County:				
Webb (Patrick Creek)	52-53	Roy A. Brown	212 Leverette Bldg., Medford, Ore.	Patricks Creek
Fresno County:				
Archer	52-53	Ben J. Byles (owner)	Coalinga	Idria
Lake County:				
Abbott	52-53	California Quicksilver Mines, Inc.	Williams	Wilbur Springs
Helen	53	W. A. Fritz and Paul Davis	Middletown	Middletown
Merced County:				
Crystal Quartz	53	Louis Sciocchetti	P.O. Box 637, Hollister	Panoche
Napa County:				
James Creek Placers	52-53	A. & J. Garcia	Middletown	James Creek
Knoxville	52-53	Ray Adams	Box 103, Monticello	Monticello
Oat Hill	52-53	Vincent Yracabel, Leo Gonzales, & L. Juarez	Middletown	James Creek
San Benito County:				
Aurora	52-53	Reyes Diaz	Box 21, Idria	Idria
El Rey	52-53	J. Quinonez	235 Second St., Hollister	Panoche
Ellery Queen	53	W. P. Schopp	Panoche	Panoche
Experanza	53	Eugene J. Jaques	756 San Benito St., Hollister	Idria
Juniper	52-53	Louis Schichetti	Box 637, Hollister	Panoche
Lucky Strike	53	Raymond J. Lucas	P.O. Box 1012, Hollister	Panoche
New Idria & San Carlos	52-53	New Idria Mining & Chemical Co.	Idria	Idria
North Star	52-53	Leonard W. Knepper	Box 98, Idria	Idria
Valley View	52	Panoche Valley Quicksilver	Box 31, Paicines	Panoche
Wonder	52-53	Paul Gonzales	1499 Ford Ave., San Jose	Panoche
San Luis Obispo County:				
Buena Vista	53	T. R. Moxness	Box 277, Cayucos	Cayucos
La Libertad	52-53	Woodrow Osborn & W. Stephenson	Box 208, Templeton	Paso Robles
Rinconada	52-53	Geo. P. Bell	Santa Margarita, Box 37A	Santa Margarita
Santa Clara County:				
	52	Ed Cooper	Santa Clara	
Guadalupe	52-53	M. L. Burrell & W. L. MacKinnon	Rt. 3, Box 835, Los Gatos	Guadalupe
New Almaden	53	David Parr, John Tobar & Herbert Perry	Almaden	Almaden

Sonoma County:				
Buckman-Dewey, Cloverdale	52-53	Buchman Laboratories, Inc., Mining Div.	1256 N. McLean, Memphis 8, Tenn.	Geyser Road
Culver Baer	52-53	C. A. Baumeister & Sons	Cloverdale	Cloverdale
Ella B. Eureka	52	Vincent C. Harrison	Rt. 1, Box 28X, Windsor	Pine Flat
Mt. Jackson	52-53	Sonoma Quicksilver Mines, Inc.	340 Pine St., San Francisco	Guerneville
Stanislaus County:				
Adobe	53	Irvin Del Ponte	Livermore	Livermore

Molybdenum

Mine	Years	Operator	Address	Location
Inyo County:				
Pine Creek	52-53	U. S. Vanadium Co.	30 E. 42d St., New York 17, N. Y.	Bishop

Platinum Group Metals

Operator	Years	Address	Location
Sacramento County:			
Natomas Company	52-53	Box 1197, Sacramento	Folsom
Yuba County:			
Yuba Consolidated Gold Fields	52-53	351 California St., San Francisco	Hammonton

Rare Earth Metals

Operator	Years	Address	Location
San Bernardino County:			
Molybdenum Corp. of America	52-53	500 Fifth Ave., New York, N. Y.	Mountain Pass

Silver

Principal silver producers in California in 1952 and 1953.
(Not less than 1,000 oz. per year.)

Mine	Years	Type of mine*	Operator	Address	Location
Amador County:					
Old Eureka	52	a	Central Eureka Mining Co.	Box 880, San Jose	Sutter Creek
Calaveras County:					
Penn		l	Penn Chemical Co., Inc.	Campo Seco	Campo Seco
Penn	53	i	New Penn Mines, Inc.	70 Pine St., New York, N.Y.	Campo Seco
El Dorado County:					
Hazel Creek	52-53	a	Hazel Creek Mining Corp.	P.O. Box 309, Placerville	Sly Park
Inyo County:					
Darwin group	52-53	m,d	Anaconda Copper Mining Co.	25 Broadway, New York, N.Y.	Darwin
Defense	52-53	k	L. D. Foreman & Co.	1354 Second Ave., Salt Lake City, Utah	Panamint Springs
Lane	53	d,m	L. D. Foreman & Co.	1354 Second Ave., Salt Lake City, Utah	Keeler
Lippincott (Lead King)	52-53	k	Lippincott Lead Mines	Box 1811, Santa Ana	Scotty's Castle
Minnietta	52	k	Finley & Vignich	Panamint Springs via Lone Pine	Panamint Springs
Pine Creek	52-53	p	U.S. Vanadium Co.	30 E. 42d St., New York, N.Y.	Bishop
Shoshone group	52	k	Anaconda Copper Mining Co.	25 Broadway, New York, N.Y.	Tecopa
Silver Reid (Lee)	52-53	m	Albert Glenn & Ambrose Aguerreberry	Box 192, Darwin	Keeler
Kern County:					
Cactus Queen	52	a	Burton Mines, Inc.	Rosamond	Mojave
Golden Queen	52	a	N. W. Sweetser	Rosamond	Mojave
Tropico	52-53	a	Burton Mines, Inc.	Rosamond	Willow Spring
Wegman group	52	b	Margaret Wegman	Rt. 1, Box 2A, Mojave	Mojave
Madera County:					
Jesse Bell	53	r	H. J. Buchenau	Star Rt. Box 17, Madera	Daulton Station
Mono County:					
Alexander (Green Monster)	52-53	a	Fowler Mining Corp.	Dyer, Nev.	

Nevada County:					
Brunswick-Idaho Maryland	52-53	a	Idaho Maryland Mines Corp.	Grass Valley	Grass Valley
Empire Star Group	52-53	a	Empire Star Mines Co., Ltd.	Grass Valley	Grass Valley
Sacramento County:					
Natomas	52-53	f	Natomas Company	Box 1197, Sacramento	Folsom
San Bernardino County:					
Bagdad-Chase	52	r	Donald F. Love	Box D, Ludlow	Ludlow
Hoffman Estate	53	d	Pacific Coast Mill & Mining Co.	1020 Highland Ave., National City	Ludlow
Mohawk	52	k	Mohawk Mines, Inc.	Nipton	Nipton
Shasta County:					
Afterthought	52	l	Coronado Copper & Zinc Co.	1206 Pacific Mutual Bldg., Los Angeles	Bella Vista
Hornet-Richmond	52	n	Mountain Copper Co., Ltd.	San Francisco	Matheson
Kennett smelter cleanings	52	v	International Smelting and Refining Co.	818 Kearns Bldg., Salt Lake City, Utah	Coram
Sierra County:					
Brush Creek	52-53	a	Best Mines Co.	Box 177, Downieville	Goodyear Bar
Oriental	53	a	Dickey Exploration Co.	Alleghany	Alleghany
Original Sixteen to One	52-53	a	Original Sixteen to One Mine, Inc.	235 Montgomery St., San Francisco	Alleghany
Siskiyou County:					
Siskon	53	a	Siskon Corp.	Box 148, Happy Camp	Happy Camp
Yuba County:					
Yuba unit	52-53	f	Yuba Consolidated Goldfields	351 California St., San Francisco	Hammonton

* LEGEND

a—lode gold mine
b—silver mine
c—gold-silver mine
d—tailings dump

f—dredge (bucket-line)
k—lead mine
l—zinc mine
m—zinc-lead mine

n—pyrite mine
p—tungsten mine
r—copper mine
v—flue dust and slag

Tungsten

Mine	Years	Operator	Address	Location
Alpine County:				
Empire	53	W. W. Whitting	Box 14, Coleville	Coleville
Valpine	52-53	Carson Tungsten Co.		Woodford
Calaveras County:				
Garnet Hill	53	North American Tungsten Mines, Inc.	312 Byington Bldg., Reno, Nev.	West Point
Fresno County:				
Garnet Dyke	52-53	Garnet Dyke Mine, c/o R. Sheridan	P.O. Box 15, Hilmar	Kings River
Garnet	52	Pacific Mining Co.	Fresno	Dinkey Creek
Jack Pot	53	Edgar A. McMurtry	Toll House	Toll House
	53	George Hall		
	53	S. H. Strickland	Box 39, Dunlap	Dunlap
Imperial County:				
Mesquite Diggings	53	D. L. Blumtach	Glamis	Chocolate Mtns.
	53	H. R. West		
Inyo County:				
Brownstone	52-53	Brownstone Mining Co.	P.O. Box 396, Bishop	Bishop
Buzzard	53	John Schober	2419 Commonwealth Ave., San Diego	Bishop
Darwin (Silver Reef)	53	R. Finley & T. Vignich	Darwin	Darwin
Darwin (Silver Reef)	53	G. F. Lund	Darwin	Darwin
Darwin (Silver Reef)	53	L. & W. Tungsten Co.	Darwin	Darwin
Elsie Girl	52-53	Ray Harvey	Box 95, Bishop	Bishop
Garnet	53	Brooks & Hogel	Bishop	Bishop
Garnet No. 2	53	Paul Priebe	157C Short St., Bishop	Bishop
Greene	53	Panamint Tungsten Mines	Box 202, Barstow	Skidoo
Hanging Valley	52-53	G. H. Hall	137 S. Main St., Bishop	Bishop
High Noon	52-53	Ralph Dahl	Lone Pine	Lone Pine
Hilltop	53	Frank B. Hudson	236 Grove St., Bishop	Bishop
Huntley (Tungsten City)	52-53	L. Hedgecook & Riley	Bishop	Bishop
Huntley (Tungsten City)	53	K. Moore	325 Grove St., Bishop	Bishop
Huntley (Tungsten City)	53	Hah's Development Co.	Bishop	Bishop
Huntley & The Little Sister	52-53	E. K. Lovelace	Box 664, Bishop	Bishop
Kilroy	52-53	A. A. Goehring	Oasis via Bigpine	Oasis
L & L	52-53	Lester Brown	Box 674, Bishop	Bishop
Moonlight	53	Lee Early	Rt. 1, Box 201, Bishop	Bishop

Oomp	53	C. E. Lindner	Box 141, Lemon Cove	Bishop
Pickup (Chipmunk)	53	Inyo Star Mining Corp.	Bishop	Bishop
Pine Creek	52-53	U. S. Vanadium Co.	30 E. 42d St., Rm. 1701, New York, N.Y.	Bishop
Pine Knot	53	C. E. Brooks		
Red Rock	53	W. C. Vasser	Lone Pine	Lone Pine
Rossi	53	Harry Davis & Geo. Lasley	Box 181, Bishop	Bishop
Round Valley	53	Round Valley Tungsten Co.	5658 Wilshire Blvd., Los Angeles 36	Bishop
Samson	53	A. L. Stewart	Bigpine	Bigpine
Shadow Mt.	53	Emil Phillips	Bishop	Bishop
Shamrock	53	Roger Ray & Kenneth Moore	336 W. Elm St., Bishop	Bishop
Shannon Canyon	53	Shannon Canyon Tungsten Mine	P.O. Box 81, Bigpine	Bigpine
St. Charles	53	Miller & Warnken	Box 37, Lone Pine	Darwin
Tarantula	52-53	M. D. Nichols	Death Valley, c/o Furnace Creek Inn	Death Valley
Tungstar	53	C. H. Hall	137 S. Main St., Bishop	Bishop
Tungsten Hill	52-53	Tungsten Hill Mine, Sterling Carter	Mercer Cavern, Murphys	Bishop
Valley	52-53	Ray & L. B. McMurray	Darwin	Darwin
Western Tungsten	53	Roger Ray, Kenneth Moore & Allen Wilkerson	336 W. Elm St., Bishop	Bishop
White Lorni	53	A. H. Peterson	Bishop	Bishop
	53	W. R. Beatty	P.O. Box 313, Bishop	Bishop
	53	Ed Eisenhauer, Jr.	320 S. San Pedro St., San Pedro	
	53	Joe McCulley	Box 53, Darwin	Darwin
Red Hill	52-53	Mt. States Uranium Co.	P.O. Box 929, Bishop	Bishop
	53	Mt. Whitney Tungsten Co.	Bishop	Bishop
	53	A. E. Noren	Bigpine	Bigpine
Skidoo	53	White Mountain Mining & Milling Co.	Star Rt., Laws	Laws
Kern County:				
Ada R.	52-53	L. C. Bills	3814 Chestnut Ave., Long Beach	Randsburg
Betty G.	53	Rolland C. Cole	Randsburg	Johannesburg
Big Bear	53	Earl Milsap, J. E. Brown, & Tom Akins	Ridgecrest	Weldon
Big Gold	53	Jack Kreta	Box 251, Randsburg	Randsburg
Billie Burke	53	Bert Johnson	Randsburg	Randsburg
Billie Burke	53	Green & Thorpe	Box 580, China Lake	Randsburg
El Rey & King	53	J. H. Christenson	Bodfish	Bodfish
Golden Star	53	R. W. Griggen	Inyokern	Inyokern
Gray Hill & Blue Rock	53	Jackson F. Wright	1104 Tent St., China Lake	Inyokern
Hi Peak & Snow White	53	Hatton & Carlson	Box 297, Inyokern	Inyokern
Little Wonder	53	Wm. Traill	Little Lake	Bakersfield
Little Wonder & Pappy	53	Tap, Inc.	Box 22, Bodfish	Bakersfield, Bodfish
Pearl Wedge	53	Chas. Stryker	Gen. Del., Johannesburg	Johannesburg
Rand	53	Kubon & Jurva, c/o Urhc A. Jurva	419 N. Emily, Anaheim	Glennville
Squaw Tit	53	Jack Cowan	Box 13, Little Lake	Inyokern

Tungsten—Continued

Mine	Years	Operator	Address	Location
Kern County (Continued):				
Tungsten V	52-53	C. L. Seager & W. Hilton	Box 712, Oildale	Havilah
Unip	53	Liebel & Beatty	Box 63, Bodfish	Isabella
	53	Baker & Cocking	Box 11, Woody	Woody
Great Western	53	Bales & Wortley	Box 321, Inyokern	Nine Mile Canyon
	53	H. H. Corbin	Rosamond	Rosamond
	53	J. V. Poisette	2525 Chester Lane, Bakersfield	Green Mts.
Madera County:				
Cedar	53	Joe Kossan	Friant	Bass Lake
Strawberry	52-53	Strawberry Tungsten Mines, Inc.	1739 Terrace Ave., Fresno 3	Clover Meadow
Mariposa County:				
Blue Dipper & Blue Spot	53	Incline Mining Co.	1770 22d Ave., San Francisco 22	El Portal
June Bee	53	F. S. Harrod	Gen. Del., Oakhurst	Ahwahnee
Mono County:				
Black Rock	52-53	Black Rock Mining Corp., c/o Wah Chang Mining Co.	137 Clarke St., Bishop	Benton
Good View	53	Nick Pappas	Box 341, Bishop	Mammoth Sta.
Hilton Creek	52-53	Blue Ridge Midway Gold Mines Co., Inc.	Box 478, Bishop	Bishop
Lone Star	53	Lone Star Mines	Coleville	Coleville
Niclii	53	Shafer, Shafer, & Schwerin	c/o M. P. Merrick, Box 815, Bishop	Bishop
Scheelore	53	Scheelore Mines	336 N. Main St., Bishop	Bishop
Valley View	53	Sigard Folwick	Tonopah, Nev.	Bigpine
White Horse	53	Arnold Williams		
	53	Piute Mining and Milling Co.	Box 100, Bigpine	
Riverside County:				
Bill Thompson	53	Lee Harnage	1001 W. Hayse St., Banning	Banning
San Bernardino County:				
Atolia	52-53	Surcease Mining Co.	214 30th St., Sacramento 16	Atolia
Blue Jay	53	Baird & Martin	Barstow	Barstow
Bright Outlook	52-53	Harry F. Heather	236 S. Oak Knoll Ave., Pasadena	Kelso
Cole	53	West American Tungsten Corp.	Randsburg	Randsburg
Columbia	53	C. F. Curtis	Baker	Baker

Emerald & Rose Marie	53	H. C. Brown	Box 247, Johannesburg	Johannesburg
Fair View	53	Martin & Martin	Box 352, Barstow	Barstow
Green Top	53	Henry Plekas	Red Mountain	Red Mountain
M. Gale	53	W. T. Ritson	Barstow	Barstow
Mary Ann	53	Adelanto Mining Co., Inc.	11478 E. Sea Drive, Whittier	Shadow Mt.
Moonlight	53	Raymond Jones	Box 171, Barstow	Barstow
Princess Pat	53	Page, Corio, & Palmer	Victorville	Victorville
Section 9	53	Walter H. Zindell	Box 27, Cadiz	Cadiz
Shadow Mt.	52-53	Just Associates	726 Story Bldg., Los Angeles	Adelanto
Standard (Riley)	53	J. Riley Bemdry	Cima	Barstow
Starbright	53	C. B. Aitchison, Jr.	1628 Alta Ave., Santa Monica	Barstow
Tenant	52-53	V. T. Bowald	Randsburg	Atolia
Tungsten King	53	Raymond Jones	Box 171, Barstow	Barstow
Whitehorse	53	J. E. Sims	Box 663, Trona	Adelanto
	53	A. W. F. Mining Co.	Adelanto	Mirage Lake
San Diego County:				
Crown Point & Metal Mtn.	53	L. B. Spaulding	Box 15, Ramona	Live Oak
Pawnee	53	F. G. Feldon	Julian	Jacumba
P. K. Tungsten	53	Pawnee Mining Corp.	1375 Blackstone Rd., San Marino	Jacumba
Tulare County:				
Baker lease	53	Kaweah Mining & Milling	1655 Riverside Dr., Los Angeles	Lemon Cove
Big Jim	52-53	Tulare County Tungsten Mines	895 Lafayette Ave., Lindsay	Exeter
Brush Creek	53	S. D. Crotsenburg	Gen. Del., Kernville	Kernville
Buckeye	53	The Buckeye Mines Co.	16946 Ventura Blvd., Encino	Three Rivers
Christmas	53	Fred Bower	Box 7, Inyokern	Inyokern
Consolidated (Harrel Hill)	52-53	Claud Rouch, Sr. & Jr.	Fresno	Orosi
Crystal Queen	53	T. A. Hazelton	Fresno	Lemon Cove
Pioneer	52-53	Good Hope Mining Co.	120 "O" St., Fresno	Three Rivers
Sherman Peak	52-53	Clifford L. Ach (deceased)		Kernville
Wheeler	53	Wheeler Mining Co.	209 E. Yosemite, Madera	Orosi
	53	Sequoia Tungsten Co.	St. Rt., Orange Cove	
Tuolumne County:				
Montezuma	53	Tuolumne-Tungsten Co.	P.O. Box 697, Sonora	Dorothy Lake

Zinc

Principal zinc producers in California in 1952 and 1953.
(Not less than 10,000 pounds per year.)

Mine	Years	Operator	Address	Location
Calaveras County:				
Penn	52	Penn Chemical Co., Inc.	Campo Seco	Campo Seco
Penn	53	New Penn Mines, Inc.	70 Pine St., New York 5, N. Y.	Campo Seco
El Dorado County:				
Hazel Creek	53	Hazel Creek Mining Corp.	P.O. Box 309, Placerville	Grizzly Flat
Inyo County:				
Big Four	52	Wooly J. Lorenz	Box 346, Lone Pine	Lone Pine
Darwin group	52-53	Anaconda Copper Mining Co.	25 Broadway, New York, N. Y.	Darwin
Defense & Lane tailings	52-53	L. D. Foreman & Co.	1354 Second St., Salt Lake City, Utah	Darwin
Le Moigne	52-53	W. V. Skinner	P.O. Box 125, Lone Pine	Le Moigne
Shoshone group	53	Anaconda Copper Mining Co.	25 Broadway, New York, N. Y.	Tecopa
Silver Reid (Lee)	52-53	Albert Glenn & Ambrose Aquerreberry	Box 192, Darwin	Darwin
San Bernardino County:				
Old Rose	52	Red Corral Mining Co.	610 S. Broadway, Los Angeles 14	Bear Lake

DIRECTORY OF SMELTERS AND MINERAL DEALERS REPORTING PURCHASE OF CALIFORNIA METALS PRODUCED IN 1952 AND 1953.

Name	Address	Location of plant	Metals reported purchased
American Smelting & Ref. Co.	120 Broadway, New York, N. Y.	Amarillo, Tex.	Zinc
American Smelting & Ref. Co.	120 Broadway, New York, N. Y.	El Paso, Tex.	Copper, gold, silver
American Smelting & Ref. Co.	120 Broadway, New York, N. Y.	Garfield, Utah	Copper, lead, gold, silver
American Smelting & Ref. Co.	120 Broadway, New York, N. Y.	Hayden, Ariz.	Copper, gold, silver
American Smelting & Ref. Co.	405 Montgomery St., San Francisco	Selby	Copper, lead, gold, silver
American Smelting & Ref. Co.	120 Broadway, New York, N. Y.	Tacoma, Wash.	Copper, lead, gold, silver
Anaconda Copper Mining Co.	25 Broadway, New York 4, N. Y.	Anaconda, Mont.	Copper, lead, zinc, gold, silver
Anaconda Copper Mining Co.	25 Broadway, New York 4, N. Y.	Great Falls, Mont.	Zinc
Bethlehem Pacific Coast Steel Corporation	20th and Illinois Sts., San Francisco	San Francisco	Iron ore
Bradley & Ekstrom	320 Market St., San Francisco	San Francisco	Manganese, chromite, iron ore
Bradley Mining Co.	Crocker Bldg., San Francisco	Stibnite, Idaho	Antimony
Braun Corporation	2260 E. 15th St., Los Angeles	Los Angeles	Quicksilver
Coast Chemical Division F. W. Berk & Co., Inc.	Sharon Bldg., San Francisco	San Francisco	Quicksilver
Columbia-Geneva Steel Division, U. S. Steel Co.	P.O. Box 269, Salt Lake City, Utah	Geneva, Utah	Manganese and iron ores
International Smelting & Ref. Co.	Kearns Bldg., Salt Lake City, Utah	Miami, Ariz.	Copper, gold, silver
International Smelting & Ref. Co.	Kearns Bldg., Salt Lake City, Utah	Tooele, Utah	Copper, lead, zinc, gold, silver
Kaiser Co., Inc.	P.O. Box 217, Fontana	Fontana	Iron ore, manganese ore, chromite
Kennecott Copper Corp.	120 Broadway, New York, N. Y.	McGill, Nev.	Copper, gold, silver
Lippincott Lead mines	Box 1811, Santa Ana	Santa Ana	Lead and zinc ore
Mefford Chemical Co.	1026 Santa Fe, Los Angeles	Los Angeles	Quicksilver
Pacific Vegetable Oil Co., Bernard T. Rocca	62 Townsend St., San Francisco	San Francisco	Quicksilver
Phelps-Dodge Corp.	40 Wall St., New York, N. Y.	Ajo, Ariz.	Copper, gold, silver
Quicksilver Procedures Ass'n., Irving Ballard, Sec'y.	407 Sansome St., San Francisco	San Francisco	Quicksilver
Sullivan Mining Co.	Wallace, Idaho	Silver King, Idaho	Zinc
Twining Laboratories	2527 Fresno St., Fresno	Fresno	Tungsten ore
U. S. Mint	Duboce & Market Sts., San Francisco	San Francisco	Gold, silver
U. S. Smelting, Refining & Mining Co.	Newhouse Bldg., Salt Lake City, Utah	Midvale, Utah	Copper, lead, zinc, gold, silver
United States Vanadium Corp.	30 E. 42d St., New York, N. Y.	Bishop	Tungsten ore
Western Gold & Platinum Works	589 Bryant St., San Francisco	San Francisco	Platinum, gold, silver*
Wildberg Bros. Smelting & Ref. Co.	742 Market St., San Francisco	San Francisco	Platinum, gold, silver*

* Gold and silver in special high-grade ores only.

DIRECTORY OF MINERAL DEALERS AND COMMERCIAL LABORATORIES

List of Mineral Dealers, Custom Mills, and Commercial Grinding Plants in California

Firm	Remarks
American Minerals Co., 840 Mission Rd., Los Angeles.	Commercial grinding of minerals.
Atkins, Kroll & Co., 320 California St., San Francisco 4.	Dealer in tungsten ores, mercury, gypsum and limerock.
Baroid Sales Division National Lead Co., 830 Ducommun St., Los Angeles.	Talc and other soft non-metallic minerals ground by contract or purchased.
Bishop Concentrate & Cleaning Co., Bishop	Custom mill; purchases tungsten ores and base metal ores.
Blood, Harry E., Co., 5028 Alhambra Ave., Los Angeles	Dealer in industrial sand and silica products.
Bradley & Ekstrom, 320 Market St., San Francisco 11	Dealer in all commercial minerals.
Brumley-Donaldson Co., 557 Howard St., San Francisco 5, and 3050 E. Slauson Ave., Huntington Park	Dealer in sand, clay, limestone, dolomite, and other minerals.
Burton Bros., Rosamond, Kern County	Custom cyanide mill. Gold and silver ores purchased.
Butte Lode Mining Co., Randsburg	Custom amalgamation mill, gold-silver ore.
Castle Crags Chrome Co., Box 126X, Castella	Dealer in or custom milling of chrome ores.
Commercial Minerals Co., 310 Irwin St., San Francisco 7	Commercial grinding by contract or minerals purchased.
Dailey Chemical Laboratories, Box 228 Oroville	Custom mill for black sands.
Empire Star Mines Co., Ltd., Grass Valley	Amalgamation, flotation and cyanide mill; gold ore and concentrates purchased.
Hidecker Co., 800 S. Mission Rd., Los Angeles	Clay grinding plant; non-metallic minerals ground by contract or purchased.
Hill Bros. Chemical Co., 2159 Bay St., Los Angeles	Grinding asbestos, and custom milling of small lots of soft non-metallic minerals.
Huntley Industrial Minerals, P.O. Box 305, Bishop	Dealer in talc, pyrophyllite, garnet sands, clay and mica.
Industrial Minerals & Chemical Co., 836 Gilman St., Berkeley	Non-metallic minerals ground by contract or purchased.
Kennedy Minerals Co., 2552 E. Olympic Blvd., Los Angeles	Non-metallic minerals ground by contract or purchased.
Los Angeles Chemical Co., 1960 S. Santa Fe Ave., Los Angeles	Dealer in non-metallic minerals.
Metals Disintegrating Co., Inc., 1069 Second St., Berkeley 10	Non-metallic mineral grinding by contract or purchase.
Mojave Mining & Milling Co., Martin Beck, Mojave	Custom mill, amalgamation and flotation.
Ontario Rock Milling Co., 7557 E. Olive, Paramount	Non-metallic minerals ground by contract or purchased. Roofing granules prepared.
Sierra Talc & Clay Co., 5509 Randolph St., Los Angeles 22	Dealer in talc and clays.

DIRECTORY OF MINERAL DEALERS AND COMMERCIAL LABORATORIES —Continued

Firm	Remarks
Southern California Minerals Co., 320 S. Mission Rd., Los Angeles	Dealer in talc, clay and other minerals.
Twining Laboratories, 2527 Fresno St., Fresno	Purchase and concentrate tungsten ores on a custom basis, also commercial grinding.
U. S. Vanadium Co., Bishop	Tungsten mill, ore purchased.
Western Talc Co., 1901 E. Slauson Ave., Los Angeles	Non-metallic mineral grinding plant; minerals ground by contract or purchased.

LIST OF COMMERCIAL ASSAY AND TESTING LABORATORIES

Firm	Services
San Francisco Area	
American Spectrographic Laboratories, 557 Minna St., San Francisco	Spectrographic analysis of minerals and water by quantitative methods. Radioactivity measurements.
Ball, C. M., 911 University Ave., Berkeley 2	Fire assay, chemical analysis of ores and minerals.
Curtis & Tompkins, Ltd., 236 Front St., San Francisco 11	Chemical analysis and specification testing of metallic ores, metals, and nonmetallic minerals.
Hall Laboratories, Inc., 200 Davis St., San Francisco 11	Consulting water chemists.
Hanks, Abbott A., Inc., 624 Sacramento St., San Francisco 11	Fire assay, chemical analysis of metals, alloys, cement, ores and minerals; physical tests of structural materials; spectrographic analysis.
Hersey Inspection Bureau, 3405 Piedmont Ave., Oakland	Engineers, chemists, and testers of building materials, foundations.
Metallurgical Laboratories, 604 Mission St., San Francisco 5	Chemical analysis of ceramic materials, chemical analysis of ores and minerals, spectrographic analysis, water analysis.
Pacific Chemical Laboratories, 617 Montgomery St., San Francisco 11	Chemical analysis of ceramic materials, chemical analysis of ores and minerals, petrographic analysis, spectrographic analysis, water analysis.
Pittsburg Testing Laboratories, 651 Howard St., San Francisco 5	Fire assay, chemical analysis of ceramic materials, chemical analysis of ores and minerals, ore dressing, beneficiation, physical tests, spectrographic analysis, water analysis.
Siefert, H. G., Laboratory, 3403 Piedmont Ave., Oakland 11	Chemical analysis of ores and minerals, physical and chemical test of petroleum products, and chemical ceramic testing.
Western Gold and Platinum Works, 589 Bryant St., San Francisco 7	Fire assay, chemical analysis of ores and minerals, ore dressing, beneficiation.
Western Machinery Co., 760 Folsom St., San Francisco 7	Ore dressing, mineral beneficiation, coal washing, sand preparation.
Los Angeles Area	
California Testing Laboratories, Inc., 619 E. Washington, Los Angeles 15	Chemical analysis of ores, minerals, ceramic materials. Physical, electronic, and environmental testing.
Dorr Co., Engineers, 811 W. Seventh St., Los Angeles 17	Ore dressing, mineral beneficiation.
Eisenauer, Ed., Jr., 322 S. San Pedro St., Los Angeles	Fire assay, chemical analysis of ores and minerals.
Herr, A. V., 5176 Hollywood Blvd., Los Angeles	Fire assay, chemical analysis of ores and minerals, and spectrographic analysis.
Hollywood Testing Laboratories, 1257 N. La Brea Ave., Hollywood 38	Fire assay, chemical analysis of ceramic materials, chemical analysis of ores and minerals, ore dressing, beneficiation, petrographic analysis, physical tests, spectrographic analysis, water analysis, X-ray diffraction.
Hunt, Robert W., Co., 6353 Miles Ave., Huntington Park	Chemical analysis of ores and minerals.

LIST OF COMMERCIAL ASSAY AND TESTING LABORATORIES—Continued

Firm	Services
Los Angeles Area—Continued	
Keldon Research Corporation, Box 2555, Terminal Annex, Los Angeles 54	Chemical analysis of ores and minerals; chemical analysis of ceramics; spectrographic analysis, water analysis, mineral evaluation.
Kennard & Drake, 3364 E. 14th St., Los Angeles 23	Chemical analysis of ceramic materials, chemical analysis of ores and minerals, ore dressing, beneficiation, physical tests, spectrographic analysis.
Los Angeles Testing Laboratory, 1300 S. Los Angeles St., Los Angeles 15	Fire assay, chemical analysis of ceramic materials, chemical analysis of ores and minerals, ore dressing, beneficiation, physical tests, spectrographic analysis, cargo inspection.
Meco Assayers, 417 S. Hill St., Los Angeles 13	Fire assay, chemical analysis of ores and minerals.
Metal Control Laboratories, 2735 E. Slauson Ave., Huntington Park	Chemical analysis of ores, minerals and metals, physical tests, spectrographic analysis, metallurgical examinations, and quantometric analysis.
Minerals Engineering, 417 S. Hill St., Los Angeles 13	Ore dressing, beneficiation of ores and minerals.
National Supply Co., The, 1524 Border Ave., Torrance	Chemical analysis of ores and minerals, ore dressing, beneficiation, physical tests.
Nelson, P. N., P.O. Box 2062, Magnolia Center, Riverside	Custom assaying.
Osborne, Raymond G. Laboratories, 110 W. Ninth St., Los Angeles 15	Chemical analysis of ceramic materials, chemical analysis of ores and minerals, physical testing of construction materials.
Quality Control Laboratory, 12232 E. Valley Blvd., El Monte	Fire assay, chemical analysis of ores, minerals and water, spectrographic analysis and physical test.
Sill, Harley A., 1011 S. Figueroa St., Los Angeles 15	Fire assay, chemical analysis of ceramic materials, chemical analysis of ores and minerals, petrographic analysis.
Smith-Emery Co., 781 E. Washington Blvd., Los Angeles 21	Fire assay, chemical analysis of ceramic materials, chemical analysis of ores and minerals, ore dressing, beneficiation, petrographic analysis, spectrographic analysis.
Southwestern Engineering Co., 4800 S. Santa Fe Ave., Los Angeles 58	Ore dressing, beneficiation of minerals.
Triplett & Barton, Inc., 831 N. Lake St., Burbank	Chemical analysis of ores and minerals, spectrographic analysis (rare earth analyses), X-ray diffraction metallography.
Truesdail Laboratories, Inc., 4101 N. Figueroa, Los Angeles 65	Chemical analysis of ores and minerals physical testing of ferrous and non-ferrous metals and alloys.
von Huene, Rudolph, 865 N. Mentor Ave., Pasadena 6	Thin and polished sections prepared.
Other Areas	
Bishop Assay Office, 126 S. Warren St., Bishop	Fire assay; chemical analysis of ores, minerals, and tungsten ores; testing laboratory.
Calaveras Assay Office, P.O. Box 645, Angels Camp	Fire assay, chemical analysis of ores and minerals, milling tests.
Clarkson Chemical Laboratory, 1550 Sixth Ave., San Diego 1	Fire assay, chemical and spectrographic analysis of ores and minerals.

LIST OF COMMERCIAL ASSAY AND TESTING LABORATORIES—Continued

Firm	Services
Other Areas—Continued	
Coast Laboratories, 1859 S. Van Ness Ave., Fresno 15	Fire assays, and chemical analysis of ores and minerals.
Engel, Martin C., Cantil	Fire assay; chemical analysis of ores and minerals.
Gardiner, Phillip M., & Associates, P.O. Box 123, Bishop	Fire assay, ores and minerals, control and umpiring of tungsten ores and concentrates.
Hornkohl Laboratories, 716 Truxton Ave., Bakersfield	Fire assay, chemical analysis of ores and minerals, analysis of oil cores, oils, muds, water, industrial hazards.
Howard, K. B. Co., P.O. Box 1207, Lindsay	Chemical analysis of ores, minerals, and water, chemical and physical test of petroleum.
Morse Laboratories, 316 16th St., Sacramento	Fire assay, chemical analysis of ceramic materials, chemical analysis of ores and minerals, ore dressing, beneficiation, physical tests, spectrographic analysis, chemical and mining engineers.
Peninsula Laboratories, 544 S. San Antonio Rd., Mountain View	Chemical analysis of ores, minerals, and metals; ore and mineral beneficiation, chemical and metallurgical research.
Rombough, M. R. Laboratories, 3069 Del Paso Blvd., North Sacramento 15	Fire assay, chemical analysis of ores and minerals, mill tests.
San Joaquin Research Laboratories, Box 1987, 2253 S. McKinley Ave., Stockton	Fire assay, chemical analysis of ores and minerals.
Scheave, Harold, P.O. Box 211, Nevada City	Fire assay, chemical analysis of ores and minerals.
Terralab., 1207 Abbott St., Salinas	Fire assays, chemical and polarographic analysis of ores and minerals, physical test of petroleum and petroleum products, and sampling.
Twining Laboratories, 2527 Fresno St., Box 1472, Fresno	Fire assay, chemical analysis of ceramic materials, chemical analysis of ores and minerals, ore dressing, petrographic analysis, physical tests, spectrographic analysis, water analysis, X-ray diffraction.
Valley Analytical & Testing Laboratories, Inc., 356 E. Main St., El Centro	Chemical analysis of ores, minerals, and water.

MINES AND MINERAL RESOURCES OF SAN MATEO COUNTY, CALIFORNIA

By Fenelon F. Davis *

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* Associate Mining Geologist, California State Division of Mines. Manuscript submitted for publication February 1, 1955.

ABSTRACT

San Mateo, one of the central Coast Ranges counties of California, embraces 454 square miles of the San Francisco peninsula south of the City of San Francisco. The geographic trend of the peninsula is north-south. It is traversed by a series of mountain ridges and intermontane valleys trending about N. 30° W.

The oldest rocks in the county are small bodies of Gabilan limestone of possible Paleozoic age. These occur as inclusions in granitic rocks, the pre-Franciscan mass of Montara Mountain biotite quartz diorite. On the east side of Montara Mountain the quartz diorite is in fault contact with the Jurassic (?) Franciscan-Knoxville group of rocks. Small patches of Cretaceous sediments are found at widely separated localities. Tertiary marine sediments ranging in age from Eocene to Pliocene are found in the Santa Cruz Mountains south of Montara Mountain. Tertiary volcanic and basic intrusive rocks are interbedded with the Miocene sediments. Pliocene and Quaternary sediments occur in Merced Valley. Quaternary sediments are also found along the alluvial plain fringing San Francisco Bay, and intermittently along the seacoast.

The San Andreas fault zone is the most prominent structural feature in the area. It traverses the entire county in a northwesterly direction for a distance of 27 miles and extends far north and south of county boundaries.

The value of the total recorded mineral production for the county, 1895-1953 inclusive, is $107,444,275. San Mateo County ranked eighteenth among the 58 counties of the state in value of mineral production for 1953. The value for that year totaled $7,941,478; mineral commodities produced included cement, crushed stone (limestone and sandstone), sand, limestone (shells), salt, magnesium salts, and gold. Clay, natural gas, petroleum, potash, stone (dimension), gems, asphalt, silver, and platinum have been reported in former years.

Black sands lenses are numerous along the seacoast southward from Half Moon Bay. They are of limited thickness and lateral extent. Ilmenite and magnetite constitute much of the fine, heavy mineral fraction of the sands. No production has been made.

Small disseminated masses of low grade chromite occur in extensive bodies of serpentine adjacent to the San Andreas fault zone. The chromite is localized near Crystal Springs Reservoirs.

The occurrence of lode and placer gold has been reported from several mountain and coastal localities throughout the county. A very small production has been reported from Pescadero Beach.

A small deposit of the manganese minerals pyrolusite and psilomelane was unearthed near Belmont during World War II. Several tons of ore were reported on the dump in 1943.

Quicksilver minerals were reported to occur near Searsville as early as 1863, and were studied in detail in 1910. Prospecting of the deposit was in progress during the spring of 1955, and some ore was produced.

The oyster shell deposits of San Francisco Bay form the basis for cement production. The two-kiln plant was established in 1924. This was enlarged to a four-kiln plant in 1927. The present owner purchased the property in 1952.

Local clays near South San Francisco were used in the manufacture of common brick and sewer pipe. The period of production lasted from 1896 until 1917.

Wave action at Pescadero Beach has been extremely effective in removing pebbles from the pebbly sandstone and conglomerate of Cretaceous age. The pebbles, which include agate, hydrolite, jasper and onyx, have been used commercially in jewelry.

Magnesium oxide, hydroxide and carbonate are prepared from bay water in a plant located at South San Francisco. Using lime as a precipitant, the magnesium is first precipitated as magnesium hydroxide. The products recovered find numerous uses in medicine and industry.

The presence of oil was noted as early as 1865. Some small producers were on record shortly thereafter. Initial production of 50 barrels per day of 43° gravity oil from a depth of 700 feet was reported. A total of 57 wells was drilled to the end of 1953 and cumulative production was 41,330 barrels. No wells were producing in 1954, but a new discovery was made in October 1955.

Crushed stone has always been one of the principal mineral products of the county. Production has come chiefly from Franciscan sandstone and limestone. Other rocks that contribute to the production figure are greenstone, chert, biotite quartz diorite, Vaqueros sandstone, and Cretaceous conglomerate.

At most localities the Montara quartz diorite is friable and deeply weathered, but tough, unweathered rock is exposed near the floor of a crushed stone quarry close to Half Moon Bay.

Individual slivers of limestone of the Franciscan-Knoxville group as much as a mile in length occur in discontinuous outcrop in the San Andreas fault zone between Crystal Springs Lake and Rockaway Beach. The limestone contains many chert lenses, is interbedded with sandstone and shale, and in fault slivers with serpentine and volcanic rocks. Various quarries in the limestone have produced crushed stone for many years.

Salt has been produced intermittently for over 50 years by the solar evaporation of sea water near Redwood City. The early holdings of numerous small enterprises have now been consolidated under one ownership. Current production is for export.

Molding sands from the San Francisco area have been distributed through northern California since the earliest days of the foundry industry. Naturally bonded sands from Millbrae and South San Francisco were most recently in use. Production ceased in 1949 owing to increased competition from synthetic foundry sands.

Gypsum board and lath products were manufactured in a Redwood City plant from crude gypsum originating at San Marcos Island in the Gulf of California.

INTRODUCTION

Pillar Point at the northern end of Half Moon Bay, San Mateo County, was first sighted in 1585 by the navigator Galli on a return trip from the Philippines to Mexico. Sebastian Vizcaino sailed from Mexico to survey the California coast and on January 3, 1603, sighted La Punta del Año Nuevo at the southern end of the county. On November 1, 1769, members of the Portola party first sighted San Francisco Bay from the hills of San Mateo.

Numerous land grants were made by the Mexican government during the early part of the nineteenth century. Woodside, the county's first settlement, became a center of lumbering activities about 1820.

San Mateo County, named for Saint Matthew, was established in 1856, and Belmont was the first (?) seat of county government. As American settlers poured into the area the old Embarcadero at Redwood City became a center of shipping and ship-building activities. The county seat was moved to this locality in 1857.

During the next few decades the bonanza kings of the Comstock lode established country estates upon which they lavished their wealth along the eastern foothills of the county.

Geography. San Mateo is one of the counties of the central Coast Ranges of California. It occupies the southern part of the San Francisco peninsula and embraces an area of 454 square miles of which over 82 percent is privately owned. The City and County of San Francisco, which owns the airport and a water system, is the largest public landowner in the county.

San Mateo County is bounded on the west by the Pacific Ocean, on the south by Santa Cruz and Santa Clara Counties, on the east by San Francisco Bay, and on the north by the City and County of San Francisco. Redwood City, located 27 miles south of San Francisco on Highway 101, is the seat of county government. The population of the county in 1950 was 234,030 (California Blue Book, p. 998, 1950). It was distributed principally as follows: San Mateo 41,531; Redwood City 25,342; Burlingame 19,817; South San Francisco 19,250; Daly City 15,066; San Carlos 14,339; Menlo Park 13,537; San Bruno, 12,409; unincorporated 50,859.

The east side of the county is protected by mountain ranges and enjoys a mild and equable climate. The monthly mean temperature at San Mateo ranges from 49.2° in January to 66.6° in July. Average annual precipitation is about 21 inches. A greater range of temperature is encountered in the mountain areas and rainfall as high as 49 inches has been reported from their western slopes.

Four state highways traverse the county in a northerly direction terminating in the City of San Francisco. Communities within the county are connected by 126 miles of primary county roads and 470 miles of maintained county roads.

Coast line trains of the Southern Pacific Company connect the bayside communities with San Francisco and San Jose.

The San Francisco municipal airport is located between San Bruno and Millbrae. A municipal airfield is located at Palo Alto and a county airport at Half Moon Bay.

Industries. New residential areas have gradually encroached on available agricultural land in San Mateo County in recent years. Cultivation has become more intensive and the value of all farm products totaled $16,112,652 in 1949. Some of the principal products include: milk, vegetables, cut flowers, beef, and poultry.

The number of manufacturing plants increased by 131 percent between 1937 and 1947. Two large steel mills and four large iron and steel foundries at South San Francisco make the primary metals industry most important in value of products produced. The food industry ranks second with canneries at Redwood City and meat packing houses in South San Francisco.

Chemicals, glass products, fabricated metal products, electrical machinery, electronic devices, machinery, and wood products are also manufactured throughout the county.

Topography. San Mateo County may be divided topographically into two mountainous areas separated by an intervening valley. San Bruno Mountain in the northeast corner of the county occupies a small rugged area. The mountain extends northwestward from South San Francisco to Daly City, a distance of about 5 miles. The elevation of the highest point in this area is 1315 feet.

The Merced Valley flanks San Bruno Mountain on the southwest. The valley is about 9 miles long and varies from a quarter of a mile to a mile in width. The widest point is at the southeast end where the valley passes into the marshes and tidal flats of San Francisco Bay. The northwest end of the valley has been drowned by the Pacific Ocean and its mouth subsequently closed by drifting sands to form Lake Merced (San Francisco County).

The northern part of the Santa Cruz Mountains occupies the remainder of the county south of the Merced Valley. These mountains include a single mountain mass (Montara Mountain) north of Half Moon Bay which is flanked on the east by a series of long narrow parallel ridges trending southeastward. An intermontane valley between Sawyer Ridge and Buri-Buri Ridge is the locus of the San Andreas fault zone. This fault valley extends for about 27 miles through the county and along its course the lakes of San Andreas, Crystal Springs, and Searsville are situated. The highest point in the county is found 4 miles east of La Honda where an elevation of 2555 feet is reached.

The east slope of Buri-Buri Ridge terminates in an alluvial plain. This plain ranges from half a mile to 2 miles in width and forms the western border of San Francisco Bay from Palo Alto to Merced Valley, a distance of 20 miles.

GEOLOGY

The geology of San Mateo County is typical of the central Coast Ranges of California. The oldest rocks in the county are bodies of crystalline Gabilan limestone of possible Paleozoic age. This limestone is found as inclusions in the Montara pre-Franciscan batholithic mass of biotite quartz diorite. On the east side of Montara Mountain the quartz diorite is in fault contact with the Franciscan-Knoxville group of Upper Jurassic (?) age. To the north the quartz diorite is overlain by marine sedimentary rocks of Eocene and Cretaceous age; to the south it is overlain by marine Miocene and Pliocene beds.

Tertiary marine formations ranging from Eocene to Pliocene age are widely distributed through the Santa Cruz Mountains in the southern part of the county. Diabase and ellipsoidal basalt are frequently intercalated with the Miocene beds. In the northern part of the county the Franciscan-Knoxville group is partly overlain by marine clays, sandstones, and shales of the Plio-Pleistocene Merced formation; and by Quaternary alluvium.

Structure

The structure of San Mateo County is complex. It is controlled by faulting, the trend of which is predominantly in a northwesterly direction, so characteristic of the general structural trend in California. The folding and crumpling of sediments are associated with faulting in many places.

The San Andreas is the most prominent fault in the area and can be traced though the entire county a distance of 27 miles. It is predominantly a strike-slip fault with right lateral displacement (relative motion of block on east side of fault is southward).

The Pilarcitos thrust fault, west of the San Andreas fault, is another important structural feature of the area. It extends from San Pedro Valley to Langley Hill, a distance of about 25 miles. Four miles south of San Pedro Valley this fault separates the quartz diorite of Montara Mountain from the Franciscan-Knoxville group. This relationship continues southward for the next 4 miles. The southern part of the fault is in Tertiary sediments.

Northwest-trending folds have been mapped in the Tertiary beds in the southern part of the county.

Rock Formations and Related Mineral Resources

After the soils and surface waters, the most important mineral products of San Mateo County are cement, clay, limestone, oyster shells, miscellaneous crushed stone, sand, salt and seawater magnesia. Small quantities of petroleum have been produced in the past.

The occurrence and relationship of these mineral deposits to geologic formations are important in evaluating the extent of known exposures, *Summary of economic geology of San Mateo County.*

Geologic age			Formations	Rock types	Mineral deposits
Era	Period	Epoch			
CENOZOIC	QUATERNARY	Recent	Terrace gravels, alluvium.	Assortment of sand, gravel, silt, clay.	Aquifers, sand, gravel, clay.
		Pleistocene to upper Pliocene	Santa Clara	Unconsolidated continental gravels and clay.	Road metal; fill rock.
	TERTIARY		Merced	Loosely consolidated marine sands; sandstone and shale; fossiliferous sandstone; volcanic ash.	Asphalt, concrete and foundry sands. Fill rocks. Abrasives.
		Pliocene to upper Miocene	Purisima	Fossiliferous sandstone, gravel. Some siltstone, clay and shale. Mostly marine but partly continental.	Petroleum reservoir rock in Half Moon Bay district.
		Miocene	Monterey Vaqueros	Marine, fossiliferous. Diatomaceous and siliceous shale and sandstone. Lower heavy-bedded sandstone and coarse conglomerate; breccia. Interbedded basalt and diabase with limestone inclusions.	Petroleum source beds. Road and fill rock. Local building stone.
		Oligocene	San Lorenzo	Marine sandstone and shale; partly fossiliferous.	(Only small exposures in county.)
		Upper Eocene	Butano	Massive, brown, marine sandstone.	No record of use.
		Paleocene	Martinez	Alternating sandstone and shale, sandstone, conglomerate.	No record of use.
MESOZOIC	CRETACEOUS	Upper	Undifferentiated	Marine. Conglomerate, sandstone, siltstone and some shale.	Road rock and fill rock.
	JURASSIC(?)	Upper(?)	Franciscan-Knoxville group	Arkosic marine sandstone; graywacke, siltstone and shale, local conglomerate, radiolarian chert, limestone, schists, Serpentine and ultrabasic intrusions.	Limestone. Road rock and fill rock. Rip-rap.
PALEOZOIC(?)			Montara quartz diorite; Gabilan limestone	Biotite quartz diorite; a few lenses of older Gabilan (?) limestone.	Road rock, fill rock. Rip-rap and building stone. (?)

and in prospecting for further deposits. The following section will describe the rock groups found in the county and shows their relationship to the mineral resources they contain. To facilitate this exposition a geologic map has been compiled showing the areal distribution of the rock formations and the location of the mineral deposits and quarries.

Pre-Franciscan-Knoxville Rocks. The oldest rocks in San Mateo County are small bodies of Gabilan limestone of possible Paleozoic age. These occur as inclusions in the quartz diorite found at Montara Mountain. Here a batholithic mass of pre-Franciscan-Knoxville biotite-quartz diorite is extensively exposed. The mountain is fringed by Eocene and Cretaceous sediments along its northern slope. The quartz diorite is in fault contact with the younger Franciscan-Knoxville group to the east and southeast, and is overlain by Tertiary sediments at its southern and at part of its western end.

The Montara quartz diorite is deeply weathered at most of its exposures and consequently has not been used extensively as a building stone. It has been quarried for crushed stone and road fill at Montara, Granada, and east of Half Moon Bay.

Franciscan-Knoxville Group. The Franciscan-Knoxville group (Upper Jurassic ?) includes a thick section of predominantly marine strata with associated intrusions of basic rocks. San Bruno Mountain and that part of the Santa Cruz Mountains east of the Pilarcitos fault consists of such rocks. The beds are chiefly sandstone with small quantities of interbedded siltstone and shale. Locally, conglomerate, radiolarian chert, altered volcanic rocks (greenstone), agglomerate, and schists are exposed. Basic igneous intrusions, largely gabbro and peridotite of probable late Jurassic age, have been altered to serpentine.

The principal mineral commodities produced from the Franciscan-Knoxville group in San Mateo County are crushed stone (limestone and sandstone) and fill rock (chert and greenstone).

Cretaceous Sedimentary Rock. Cretaceous strata in San Mateo County include those rocks mapped by Branner, Newsome and Arnold (1909) as the Chico formation (Upper Cretaceous). The formation comprises thick-bedded sandstone and conglomerate with small amounts of shale. These rocks are exposed in the foothills about 4 miles west of Palo Alto and in a 9-mile strip along the coast near Pigeon Point.

Tertiary Sedimentary Rocks. Tertiary sedimentary rocks occupy most of the area in the southwestern part of the county. They extend southward from Half Moon Bay and westward from the San Andreas fault. The oldest Tertiary sediments in the county are part of the Martinez formation of Paleocene age. They are found in a narrow strip bordering the north side of Montara Mountain (Darrow, 1950 unpublished thesis) and extend inland from the seacoast a distance of about 6 miles. Cretaceous rocks underlie the Martinez rock on the north. The Pilarcitos fault separates the Tertiary-Cretaceous rocks from the Franciscan-Knoxville group in this locality.

The upper Eocene marine Butano sandstone occurs east of Pescadero at the southern end of the county. These rocks are massive, brown and buff-colored sandstone. At Butano Ridge the Butano sandstone is flanked by the San Lorenzo formation of Oligocene age. The latter formation consists of marine clayey shales intercalated with fine grained sandstone.

The Miocene epoch in the county is represented by Vaqueros (?) sandstone and the Monterey shale. The Vaqueros is the older formation. It consists of thick bedded marine sandstone and conglomerate, interbedded with minor amounts of dark shale, especially near the top. The Vaqueros extends northwestward as long belts in the upper part of the Santa Cruz Mountains west of the San Andreas fault. It has been used locally in road construction.

Minerals, of interest to collectors, reported to occur in San Mateo County.

Agate
Analcime
Apatite
Apophyllite
Biotite
Calcite
Calomel
Celadonite
Chalcedony
Chromite
Cinnabar
Dolomite
Eglestonite
Epidote
Galena
Garnet
Hornblende
Hydromagnesite
Ilmenite
Jasper
Lawsonite
Magnesite
Margarite
Magnetite
Mercury
Montroydite
Opal
Orthoclase
Plagioclase
Psilomelane
Pyrite
Pyrolusite
Pyroxene
Quartz
Silver
Sphalerite
Titanite

The Vaqueros is overlain on the west in most places by the Monterey formation. The Monterey formation is largely a diatomaceous shale, soft to flinty, with massive sandstone.

The Purisima formation of upper Miocene to middle Pliocene age overlies the Miocene Monterey sediments in a foothill belt extending southeastward from Half Moon Bay. This formation includes marine conglomerate, sandstone and shale; the shale is partly diatomaceous.

In Merced Valley in the northern part of the county the sediments of the Plio-Pleistocene Merced formation are extensively exposed. These consist of marine clay, sandstone, shale, and conglomerate. The upper part of the Merced formation contains a deposit of light yellow sands which may be of Pleistocene age. Some of this material has been mined, processed, and used as an aggregate in asphalt mix and as foundry sands. In the eastern part of the Merced Valley the Merced formation is overlain by Quaternary alluvium.

A narrow strip of the Santa Clara formation is found west of the San Andreas fault near Woodside. This formation contains fresh water beds of gravel, sand and clay. The Santa Clara formation may be, in part, the non-marine equivalent of the Merced.

The oil-bearing sediments of San Mateo County are included in the Tertiary beds. The petroliferous formations are the lower Purisima at La Honda; and the middle Purisima on the Purisima anticline, at Purisima Creek and at Tunitas Creek. The details of development at these localities are discussed in the petroleum section of this report.

Tertiary Igneous Rocks. Tertiary igneous rocks are associated with the Tertiary sediments just east of La Honda. The rocks consist of intrusive diabase, basalt flows and intrusions, and tuffs. The igneous rocks crop out in a series of disconnected patches extending in a northwestward direction for a distance of 17 miles. The massive diabase is often intrusive along bedding planes in the Miocene shale.

Quaternary Sediments. The surface deposits along the western margin of San Francisco Bay consist of Quaternary alluvium. These deposits extend northwestward into the Merced Valley. Usually they are coarse-grained and thick near the foothills but become fine-grained and thin toward the water line.

Marine terrace deposits occur intermittently from Half Moon Bay to Año Nuevo Point. They consist of thin bedded sand, beds of fragmentary shale, waterworn gravel, and alternating thin beds of sand

and gravel. The Quaternary deposits on the south side of San Gregorio Creek attain a thickness of 60 feet (Branner and others, 1909).

Wind-blown sands of recent origin occur at intervals along the San Mateo coastline from Edgemar to Año Nuevo Point. They are currently mined at Edgemar, Pescadero, and Rockaway Beach and used in the preparation of asphalt and concrete mixes. Similar deposits occur near Half Moon Bay where they were mined years ago.

Clays and silts are constantly accumulating in the marshes fringing San Francisco Bay. The muds deposited are dredged with the oyster shells and used in the manufacture of cement.

MINES AND MINERAL DEPOSITS

The recorded mineral production of San Mateo County 1895-1953 inclusive, is valued at $107,444,275. The principal commodities produced have been: cement, magnesium compounds, crushed stone (sandstone, limestone and granite), limestone (shells), and salt. Moderate quantities of common clay products and sand have been produced. A small production of petroleum, natural gas, sand and gravel, gems, bituminous rock, potash, gold, silver, and platinum has also been recorded.

San Mateo County ranked eighteenth among the 58 counties of the state in value of mineral production during 1953. Mineral commodities produced in that year amounted to $7,941,478.

For over 85 years the surface waters of the county have been impounded in the series of lakes located along the San Andreas fault zone. These waters have partially supplied the City of San Francisco and other cities and towns along the peninsula.

Metallic Mineral Commodities

Black Sands

A study to determine the nature of minerals in black sand streaks and the composition of heavy minerals in average beach sands was recently made by C. O. Hutton (1952) at Stanford University. This study was made on beach material lying between Half Moon Bay and Monterey Bay. Black sands are relatively numerous in this area, but are of limited depth and lateral extent. In many cases they are of a transitory nature and may be concentrated during stormy weather. The black sands tend to be finer grained than sands showing little accessory mineral concentration and the ratio of heavy to light minerals increases notably with the decrease in grain diameter.

Hutton found that the light fractions of the sands (those minerals with specific gravity of less than 2.88) are composed of feldspars, quartz, acid volcanic glass, calcite, clay pellets, mica, glauconite, and fragments of calcareous and siliceous organic remains. Ilmenite and magnetite make up much of the heavy mineral fraction of the sands. Other prominent heavy minerals present are: amphiboles, pyroxenes, epidote, garnet, and chromite. Minerals occasionally found include: apatite, aragonite, allanite, cassiterite, chrysoberyl, galena, gold, monazite, olivine, pyrite, rutile, uranoan-thorite, topaz, tourmaline, vesuvianite, and zircon.

It was noted that all the more common minerals in the beach sand have been found in assemblages of heavy mineral fractions prepared

Mineral production of San Mateo County, 1895-1953.

Year	Salt		Brick		Limestone		Miscellaneous stone,[2] value	Miscellaneous and unapportioned		
	Tons	Value	M	Value	Tons	Value		Amount	Value	Substance
1895								5,000 tons	$5,000	Clay.
1896								1,000 bbls. 500 bbls.	1,250 1,250	Petroleum. Cement.
1897							$40,000			
1898			1,140	$7,000			70,000			
1899			2,870	24,225			34,000			
1900			225	9,000			7,500			
1901	40	$400	500	9,070			6,000	17 tons	255	Asphalt.
1902	6,500	16,000	200	8,000			301,120	5,000 tons	5,625	Clay.
1903	7,700	25,000	3,100	77,500			150,000			
1904	12,000	62,500	3,902	56,436			113,866	3,000 bbls.	6,000	Petroleum.
1905	16,000	67,500	5,902	61,436			75,000			
1906	14,900	44,920	6,613	67,000			111,823			
1907	14,000	56,000	8,078	86,285			2,111			
1908	23,800	60,900	4,494	63,231	37,687	$17,451	89,142			
1909	22,100	95,400	1,346	38,405	120,306	96,245	90,221		500	Gems.
1910	26,000	64,750	1,350	37,250	111,382	89,106	88,766			
1911	27,500	55,000	1,350	43,000	93,500	74,800	61,185			
1912	33,000	80,000	1,400	40,500	102,300	66,495	29,587			
1913	28,000	72,250	1,418	44,680	138,544	78,506	18,635		300	Gems.
1914	27,500	76,750	950	24,074	153,329	75,941	34,648	81,000 tons 6,581 bbls.	34,120 845 200	Sandstone. Lime. Gems.
1915	25,500	63,750	715	19,550	[1]		93,391		100 1,100	Gems. Other minerals.
1916	28,540	70,807	986	38,121			25,663	593 tons	732 85	Pottery clay. Gems.
1917	36,483	114,689					71,668		150 20,656	Gems. Brick and tile, magnesium chloride, potash.
1918	26,434	144,604					34,164		15,044	Magnesium chloride, potash.
1919	30,238	136,190					42,235		63,246	Other minerals.
1920	37,409	206,897					46,040	322 bbls.	966 39,200	Petroleum. Magnesium salts, potash.
1921	32,587	167,022	[3]				61,697	322 bbls.	966 27,407	Petroleum. Brick, magnesium chloride, potash.
1922	32,428	149,302					60,009		34,984	Magnesium salts, petroleum, potash.
1923	35,757	199,192					96,815		33,809	Magnesium chloride, petroleum, potash.
1924	54,258	205,176					75,078		21,917	Gems, magnesium chloride, petroleum, potash.
1925	31,325	155,925					90,757		1,330,831	Cement, gems, magnesium chloride, natural gas, petroleum, potash.
1926		[3]					77,470		1,816,383	Cement, magnesium chloride, natural gas, petroleum, salt.
1927		[3]			[3]		129,802		1,734,036	Cement, limestone, natural gas, petroleum, salt.
1928	[3]				[3]		251,602		3,076,971	Cement, limestone,[4] magnesium carbonate, natural gas, petroleum, salt.

1929	[3]	-----	-----	-----	[3]	-----	278,839	-----	3,393,940	Cement, limestone,[4] magnesium carbonate, natural gas, salt.
1930	[3]	-----	-----	-----	[3]	-----	340,490	-----	2,159,447	Cement, limestone,[4] magnesium carbonate, natural gas, salt.
1931	[3]	-----	-----	-----	[3]	-----	219,715	-----	2,010,794	Cement, limestone,[4] magnesium carbonate, natural gas, salt.
1932	[3]	-----	-----	-----	[3]	-----	169,689	-----	1,173,761	Cement, limestone,[4] magnesium carbonate, natural gas, salt.
1933	[3]	-----	-----	-----	[3]	-----	75,752	-----	1,493,728	Cement, limestone,[4] magnesium carbonate, natural gas, petroleum, salt.
1934	[3]	-----	-----	-----	[3]	-----	24,000	-----	1,538,490	Cement, limestone,[4] magnesium carbonate, natural gas, petroleum, salt.
1935	[3]	-----	-----	-----	[3]	-----	98,488	-----	1,491,671	Cement, limestone,[4] magnesium carbonate, salt.
1936	[3]	-----	-----	-----	[3]	-----	101,845	-----	2,308,962	Cement, limestone,[4] magnesium carbonate, salt.
1937	[3]	-----	-----	-----	[3]	-----	85,680	-----	2,225,104	Cement, limestone,[4] magnesium carbonate, salt.
1938	[3]	-----	-----	-----	[3]	-----	[3]	-----	2,026,217	Cement, limestone,[4] magnesium carbonate, salt, miscellaneous stone.
1939	[3]	-----	-----	-----	[3]	-----	65,392	-----	2,353,503	Cement, limestone,[4] magnesium carbonate, salt, petroleum.
1940	[3]	-----	-----	-----	[3]	-----	76,497	-----	2,544,114	Cement, limestone,[4] magnesium carbonate, petroleum, salt.
1941	[3]	-----	-----	-----	[3]	-----	120,541	-----	3,305,072	Cement, limestone,[4] magnesium carbonate, petroleum.
1942	-----	-----	-----	-----	[3]	-----	109,901	-----	3,764,595	Cement, limestone,[4] magnesium salts.
1943	-----	-----	-----	-----	[3]	-----	165,363	-----	2,876,071	Cement, limestone,[4] magnesium salts.
1944	-----	-----	-----	-----	[3]	-----	189,322	-----	2,263,203	Cement, limestone,[4] magnesium compounds.
1945	-----	-----	-----	-----	[3]	-----	273,824	-----	2,089,684	Cement, limestone,[4] magnesium compounds.
1946	-----	-----	-----	-----	[3]	-----	2,965,755	-----	2,952,122	Cement, limestone,[4] magnesium compounds.
1947	-----	-----	-----	-----	[3]	-----	1,184,602	-----	4,149,422	Cement, limestone,[4] magnesium compounds, crushed stone.
1948	-----	-----	-----	-----	[3]	-----	738,085	-----	4,968,946	Cement, clay. limestone,[4] magnesium compounds, crushed stone.
1949	-----	-----	-----	-----	[3]	-----	767,229	-----	4,499,783	Cement, clay, limestone,[4] magnesium compounds, crushed stone.
1950	-----	-----	-----	-----	[3]	-----	[3]	-----	6,744,555	Cement, clay, limestone,[4] magnesium compounds, sand, crushed stone.
1951	[3]	-----	-----	-----	[3]	-----	671,000	-----	6,119,397	Cement, clay, gold, limestone,[4] magnesium compounds, sand, silver, crushed stone.
1952	[3]	-----	-----	-----	[3]	-----	[3]	-----	7,930,053	Cement, clay, gold, limestone,[4] magnesium compounds, platinum, sand, silver, crushed stone.
1953	[3]	-----	-----	-----	[3]	-----	[3]	-----	7,941,478	Cement, clay, gold, limestone,[4] magnesium compounds, sand, silver, crushed stone.
Totals	629,999	$2,390,924	[3]46,539	$754,763	[4]757,048	$498,544	$11,202,004	-----	$92,444,275	
Grand total value	------$107	,444,275								

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[1] The limestone produced in San Mateo County is used as crushed stone and is included under Miscellaneous Stone. Previous to 1915 it was erroneously classified as industrial limestone and tabulated under that heading.

[2] Includes crushed stone, rubble, sand, gravel.

[3] See under 'Unapportioned.'

[4] Includes shells dredged from San Francisco Bay.

from Cretaceous and Tertiary sandstones, siltstones and volcanic ash beds in the area. The heavy mineral fraction of sands in the vicinity of the Montara quartz diorite contain: hornblende, biotite, zoisite, zircon, sphene, opaque iron oxides; but rarely monazite. The heavy fractions from soft brown sandstone of the Merced formation consisted chiefly of green hornblende, augite, and epidote. The Purisima "sandstone," composed of fine rhyolite glass particles, produced a heavy mineral assemblage of augite and hornblende. This fact accounted for the predominance of the latter minerals in the fine fractions (minus 250 mesh) of beach sands near Butano, San Gregorio, and Pomponio Creeks. No suggestions were made as to the source of the thorite.

Chromite

Chromite, the ore of chromium, occurs in the peridotites of the Coast Ranges. The peridotite rocks are composed of magnesium-iron-silicate minerals, chiefly olivine, enstatite, and augite. Magnetite may be an accessory mineral. A peridotite containing over 95 percent olivine is termed dunite, and is the most favorable host rock for chromite. A peridotite containing less than 95 percent olivine and consisting chiefly of enstatite is called saxonite. Chromite also occurs in saxonite rocks where it may be encased in a thin rind of dunite. The ratio of dunite to saxonite in peridotite masses is extremely variable.

Olivine and enstatite both alter to the mineral serpentine so that in most cases the varieties of peridotite cannot be distinguished since they have completely changed to serpentine rock.

Chromite may occur as pods or lenses or as individual grains disseminated through the serpentine or unaltered peridotite. Chromite can usually be identified by its black color, its brown streak, and its relative weight (specific gravity 4.4).

According to Walker and Griggs (1953) "Near Crystal Springs Reservoirs, San Mateo County, low-grade chromite ore occurs in small bunches in the serpentinized ultramafic masses in and adjacent to the San Andreas fault zone."

Gold, Silver, and Platinum

An early report of the State Mineralogist (Irelan 1888) mentions a "quartz ledge on Deniston Peak which assays a few dollars to the ton, and from which specimens showing free gold have been obtained." This quotation no doubt refers to quartz veins in the Montara granitic rock, which are also the source of fine gold found downstream along Dennison Creek. The creek empties into Half Moon Bay where "placer mining has, at intervals, been carried on at several points along the seashore with varied success." A ledge of quartz which "is said to assay well in gold and silver" was also reported from the Durham ranch on Tunitas Creek.

A report by Huguenin (1920) describes early prospecting in the county for gold and silver.

> Occasional small quartz stringers carrying values in gold have been discovered in San Mateo County, none of which are of sufficient extent or richness to be of economic importance. These stringers occur in the Franciscan rocks and are found in local zones of fracture in the metamorphosed sandstones. Several claims were filed on Black Mountain in the San Bruno Mountain group, just south of the San Francisco County line at Visitacion, and some small development work done. The veins uncovered were too poor for exploitation and the claims were abandoned.

> A fairly well defined quartz vein, 30 inches in width, occurs on the ranch of J. M. Macdonough, ½ mile southeast of Searsville Lake, striking almost due north and south. It outcrops on the Stanford Estate to the south. The vein, a highly oxidized and iron-stained quartz containing some calcite, is deposited in serpentine in the brecciated zone of the San Andreas fault, between walls of jasper and sandstone. It carries, besides gold, some silver and galena.
>
> In the early seventies a hermit by name of Dominico Grosse squatted on the land owned by the Stanford Estate and worked occasionally up to the time of his death (1915) developing the vein by digging some pits and trenches to expose it. He obtained some specimens rich in galena, which led to the circulation of highly colored reports concerning the richness of the vein. Recently examinations of the property at the instigation of the owner proved it to be of no commercial value, as the deposit is local, and geological conditions here are not favorable to ore deposition.
>
> Some samples taken across the 30″ face of the vein exposed in the open cuts gave an average assay value of 0.03 oz. gold, 1.10 oz. silver, 0.8 percent lead.
>
> An interesting discovery was made on property belonging to the South San Francisco Land and Improvement Company by T. V. Barton, in March 1919.
>
> Two parallel veins, one of which has been developed by a 75′ shaft and appears to average about six feet in width, were found outcropping on the hill behind the new high school on the edge of the town of South San Francisco.
>
> The vein upon which the work is being done carries lead, zinc, and silver values, a grab sample from which assayed about 20 ounces in silver. The vein strikes N. 40° W. and dips 60° south. Three men were employed when the property was visited in June 1920.

During 1952, 3 ounces of gold, 1 ounce of silver, and a small quantity of platinum were produced from placers in the vicinity of Pescadero Beach by small scale methods.

Manganese

Manganese was discovered near Belmont during World War II and was reported by Henry G. Hubbard (1943) as follows:

> Manganese Discovery in San Mateo County.
>
> Redwood Material Company's Quarry. This deposit is at Ralston Avenue, Belmont, between the Bayshore Highway and the Southern Pacific Railroad adjacent to the Coast Highway, in T. 5 S., R. 4 W., M.D. A vein strikes north in the small hill now being quarried for road-building material. The dip is 45° E. and the width is reported to be four feet. The vein extends for a distance of 300 feet along the quarry floor. Much of it is covered by loose dirt.
>
> Considerable silica accompanies the manganese oxides observed in place, but several tons of ore on the dump showed bunches of the high-grade oxides psilomelane and pyrolusite. The hill being quarried and a small area surrounding it consists of typical Franciscan rocks and there is a large tonnage of clay colored by iron oxides. This clay is not strictly an ocherous limonite but it has possible value as a camouflage material.
>
> The quarry is owned in fee by Redwood Material Company, Maple Street, Redwood City, California. President C. B. Stoner contemplates opening the manganese vein formerly exposed in the quarry floor and bulldozing an opencut to a depth of 10 or 15 feet.

This area has been subsequently levelled and is now covered by a housing subdivision.

Quicksilver

The occurrence of mercury minerals was mentioned in a report by Bradley (1918) who stated:

> Cinnabar was early noted on the Corte de Madera Rancho near Searsville in San Mateo County, west of Palo Alto. Some prospecting was done about 1863, but nothing of commercial value was found.
>
> About 1910, minute yellow crystals of the mercury oxychloride, eglestonite (Hg_4Cl_2O) were identified by A. F. Rogers, about 5 miles west of Palo Alto in

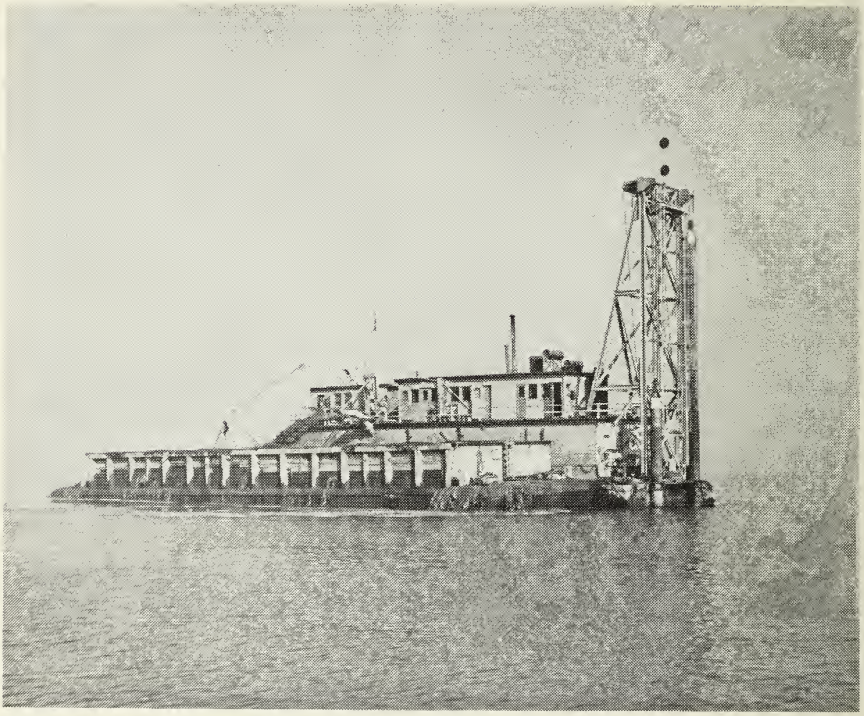

FIGURE 1. Suction dredge mining oyster shells from floor of San Francisco Bay. *Photo courtesy of Ideal Cement Company.*

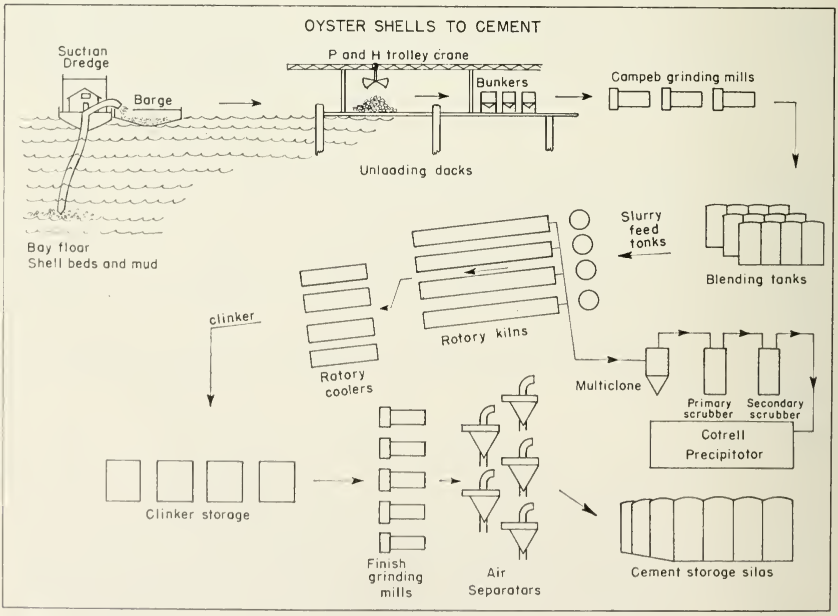
OYSTER SHELLS TO CEMENT
Suction Dredge
Barge
Bay floor
Shell beds and mud
P and H trolley crane
Bunkers
Unloading docks
Campeb grinding mills
Blending tanks
Slurry feed tanks
Rotary kilns
Rotary coolers
clinker
Multiclone
Primary scrubber
Secondary scrubber
Cotrell Precipitator
Clinker storage
Finish grinding mills
Air Separators
Cement storage silos

FIGURE 2.

> seams and cavities in a similar siliceous material to that so common in the serpentine of the cinnabar districts. The crystals showed on analysis 88.0% Hg and 7.4% Cl, and were associated with cinnabar, mercury, calomel, dolomite, magnesite, opal and quartz.

This locality, about ⅝ mile southeast of Upper Emerald Lake is situated in the central part of an irregular mass of serpentine. The serpentine mass is about a mile wide and extends for 3 miles in a northwestward direction. The area is about a mile east of the San Andreas fault zone which also trends northwestward. Small isolated outcrops of silica-carbonate rock indicate that shearing and alteration have occurred in the serpentine.

During the winter of 1954 the locality was called to the attention of H. B. Pigott, a San Francisco engineer who has been actively prospecting the area.

At the surface the serpentine has been weathered to an ocherous clay some of which contains cinnabar. At least five bulldozer trenches have been cut to a depth of 15 feet in an attempt to trace the ore shoot. Below the surface-clay in these trenches cinnabar occurs in a highly fractured and opalized serpentine where it appears as a coating on the fracture planes. Native mercury and metacinnabar are in vugs in the silica-carbonate rock.

Ore from an open-cut 25 feet deep and 50 feet in diameter was trucked to the furnace of Buckman mines, Sonoma County, and to Palo Alto Mining Company, San Jose.

Old trenches immediately to the west and about a quarter of a mile to the northwest bear witness to previous prospecting at an unreported date. The land in the area is privately owned and is not open to mineral location.

Nonmetallic Mineral Commodities

Cement

Oyster shells, *Ostrea lurida* Carpenter, form the basis of the cement industry in San Mateo County. These shells were described by Packard (1918) as:

''shells of medium size, ellipsoidal; surface laminated and sometimes irregularly plaited; beak prominent; hinge toothless.''

He also stated that the native oyster has been reported under several varietal names. It is a hardy species, having a general distribution within the bay besides occurring in the shallower waters outside the Golden Gate. It is apparently restricted by the distribution of the type of bottom that affords suitable support for the young. Living specimens were dredged in depths as much as 4 fathoms. Shells were encountered frequently within the Golden Gate in 19 fathoms. The shells being light are quite easily shifted by the currents from the shallow waters to regions of deeper water. The western specimen possesses a much thinner shell than does the eastern form.

An attempt was made early in California history to establish an oyster industry in San Francisco Bay. A description of these early activities is quoted from Hoover (1937) as follows:

> John Stillwell Morgan, a frugal, industrious man and a native of New York, was made captain of the schooner 'Telegraph' then (1846) plying the sea in the oyster business. Sailing in 1849 for California in the bark 'Magdella,' he arrived in San Francisco and thoroughly prospected the Bay for oysters without success. He then went to the mines and afterward to Oregon, where he again engaged in the oyster business.

> On the tidelands of the Bay from San Bruno Point southward as far as San Francisquito Creek, native oysters had flourished for untold centuries. After the building of the transcontinental railroad in 1869, Eastern oysters were imported and planted along the Bay shore off San Mateo County. Several companies engaged in this pursuit, most of them being finally consolidated into the Morgan Oyster Company. . . .
>
> The Morgan Oyster Company was formed in 1887 when Morgan took in four partners. With the formation of the new company, the transplanting of the bivalves from Shoalwaters Bay, Washington Territory, to the vicinity of Mission Creek, south of San Francisco, was begun.
>
> The business did not come up to expectations. In the course of time, the oyster industry ceased, and the Morgan holdings were purchased by the Pacific Cement Company, which now dredges the Bay for lime which it uses in making cement. The office building of this company on the wharf at Redwood City is one of the old oyster houses that has been moved from the piles on which it was originally built south of Dumbarton Bridge, where the piles remain.

Ideal Cement Company (Pacific Portland Cement Company). Location: Near the east end of Harbor Road, Redwood City. Owner: Ideal Cement Company, Redwood City; Cris Dobbins, president; S. D. Sajkowsky, plant manager; P. O. Box 669, Redwood City.

The company operates 14 plants and is the third largest cement producer in the United States. The plant was built by the predecessor company in 1924 and included two Allis-Chalmers rotary cement kilns. It was enlarged in 1927 when two Traylor rotary kilns and auxiliary equipment were added. The present owner acquired the property in 1952.

The use of oyster shells as a source of lime makes this operation particularly distinctive. A recent deposit of oyster, clam, and mussel shells extends along the floor of San Francisco Bay between Millbrae in San Mateo County and Alviso in Alameda County. The shells represent the debris of extensive lime oyster beds which formerly flourished in the area. The shell beds are over 25 feet thick in some localities and are often separated from each other by layers of mud. These deposits were acquired many years ago from the Morgan Oyster Company. The company controls about 30,000 acres of bay floor in this vicinity which represents many millions of tons of high-grade limestone. An average analysis of old shells was reported by Logan in 1947 as follows:

	SiO_2	Al_2O_3	Fe_2O_3	CaO_3	$MgCO_3$
Shells #4	0.56%	0.31%	0.19%	95.34%	trace

The other ingredients required in the manufacture of cement such as silica, alumina, and iron are provided by the mud accompanying the shells and by the addition of suitable proportion of iron-rich rock and iron scale.

The shells and mud currently mined lie at a depth of from 10 to 20 feet below the surface of the water. They are removed by two suction dredges maintained by the marine department of the company. The *Texas* dredge operates with a 15-inch suction pipe while the *Golden Gate* dredge operates with a 16-inch suction pipe. The suction end of each pipe is fitted with a cutter and the *Texas* dredge is powered by a 400-horsepower diesel engine. The *Golden Gate* is powered by 170-horsepower Atlas diesel engines. Smaller diesel engines on each dredge operate the auxiliary equipment. Shell production is at the rate of 300 cubic yards per hour. The shells are pumped to barges waiting alongside and when filled are towed by company tugboats to the receiving docks near the plant at Westpoint Slough.

At dockside the shells are unloaded to a stockpile by a P and H trolley crane using a Brownhoist bucket of 4-cubic-yard capacity. The crane is also used to transfer shells from the dock stockpile to three 100-ton bunkers feeding the grinding mills.

Grinding is done in three compeb mills 7 by 26 feet in size and two compeb mills 8 by 26 feet in size. Water is added and the mills make a complete reduction to slurry in an open grinding circuit without the use of screens. The slurry is pumped to 12 vertical storage tanks where it is aerated and mixed.

The slurry passes from storage to four feed tanks serving a battery of four oil-fired counter current rotary cement kilns. The latter includes two Allis-Chalmers 10 by 9 by 235-foot kilns and two Traylor 11 by 10 by 235-foot kilns. The intake ends of the kilns are equipped with about 4000 feet of chain to increase their capacity. A maximum temperature of 2700 to 2800° F is reached in the kilns. The hot gases from the kilns receive a double scrubbing through a multiclone dust separator and a Cotrell electrical precipitator before being discharged to the atmosphere.

The hot clinker, minus 1 inch in size, is discharged at the firing end. The clinker passes to four rotary coolers, 8 by 70 feet in size, and is discharged at a temperature of about 250° F. From this point the clinker can be directed to a storage pile or to five finish grinding mills. The latter include two 8 by 26-foot and three 7 by 26-foot units. The pulverized clinker is directed to air separators. The heavy fraction is returned to the mills for regrinding and the light fraction (finished cement) is pumped to silos.

This storage facility consists of three banks of four silos having a total capacity of 200,000 barrels. About 75 percent of the cement is shipped in bulk. About 12,000 connected horsepower are required to run the plant which employs 241 persons and has a rated capacity of 2,300,000 barrels per year.

Clay

Clay was mined from a pit near Cooley's Landing in 1874. This clay was used by Hunter, Shackelford and Company who manufactured brick in a neighboring plant for use in the old Palace Hotel in San Francisco. The brick operation ceased upon completion of the hotel in 1875.

Bricks were made from local clays continuously from 1896 to 1917. The Baden Brick Company was located at tidewater 1½ miles east of South San Francisco. A light yellow, sandy clay was used and the bricks were made by the stiff mud process. Common and repressed brick, and hollow tile were fired in a Hoffman kiln.

The Steiger Terra Cotta and Pottery Works, incorporated in 1898, was established in the same locality. Although most of the clay used was imported from Amador County, local clays were used in the manufacture of pressed brick and sewer pipe. The plant was destroyed by fire in 1917.

The West Coast Porcelain Manufacturers established a modern plant near Millbrae Station during the nineteen twenties. Vitreous sanitary porcelain products were manufactured from imported raw materials.

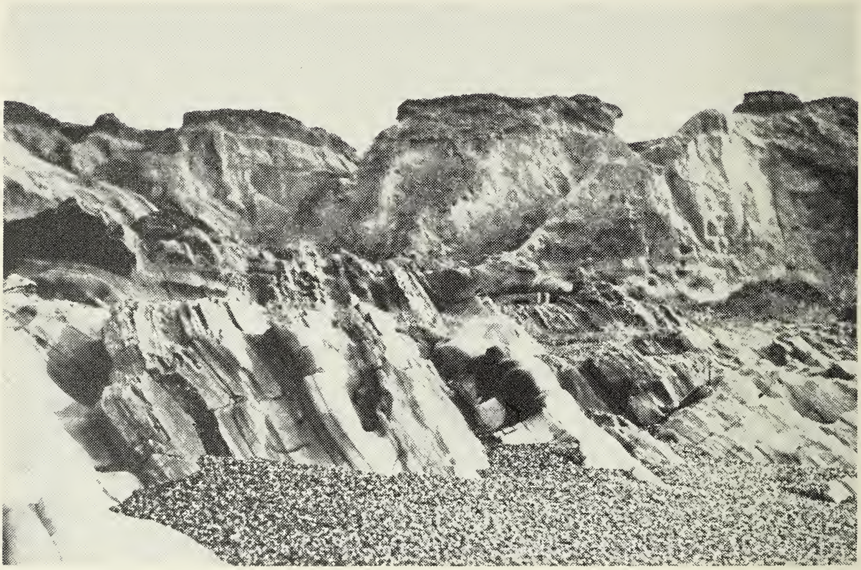

Figure 3. West-dipping Cretaceous pebble sandstone unconformably overlain by Quaternary terrace. Pebbles in foreground have been weathered out by wave action. Pebble Beach, view south.

Gems

Naturally polished pebbles of semi-precious stones are found along some of the California beaches. One of the most interesting accumulations occurs at Pescadero Beach about 45 miles south of San Francisco.

At this locality beds of Cretaceous sandstone and shale strike north 30° west and dip 60° southwest. Streaks of pebbles of variable thickness are distributed irregularly through sandstone beds. The relentless action of the waves beating against the exposed sandstone beds gradually releases the pebbles which accumulate on a small crescent-shaped beach leaving behind in the host rock a lacy network of pseudo molds.

The pebbles are composed of siliceous minerals, chiefly chalcedony, which are highly resistant to abrasion. Chalcedony, SiO_2, is the cryptocrystalline form of quartz. It is translucent to opaque and occurs in a wide variety of colors owing to impurities. A number of varieties of chalcedony occur which differ in color, pattern, and texture, and are termed agate, chert, hydrolite, jasper, and onyx.

Cut and polished pebbles were formerly produced commercially, but this section of the beach is now included in the San Mateo County Park system, and the removal of pebbles is illegal.

Magnesium Salts

Merck and Company, Inc., (Marine Magnesium Products Corporation—Marine Chemical Company). Location: Point San Bruno, at the east end of East Grand Avenue, South San Francisco.

The Marine Chemicals Company, Ltd., was incorported in 1927 to develop a process for the recovery of magnesium salts from sea water. A pilot plant was installed in 1928 with the capacity to produce 1,000 pounds of magnesium carbonate daily. In 1930 the company executed a contract to supply Morton Salt Company with magnesium carbonate. To meet this demand the plant capacity was expanded to 3 tons per day.

The company was recapitalized in 1939. The name was changed to Marine Magnesium Products Company. By this time capacity had increased to 30 tons per day. In 1951 the company was sold to Merck and Company, Inc., and the plant is now known as the Marine Magnesium Products Division.

Although the extraction of magnesium from sea water involves a relatively simple principle, the commercial process is quite complex. Magnesium occurs in sea water chiefly as magnesium chloride and to a lesser degree as magnesium sulfate as shown in the accompanying table.

*Salts in solution in sea water.**

Sodium chloride	$NaCl$	77.758	(Common salt)
Magnesium chloride	$MgCl_3$	10.878	
Magnesium sulfate	$MgSO_4$	4.737	(Epsom salt)
Calcium sulfate	$CaSO_4$	3.60	(Gypsum)
Potassium sulfate	K_2SO_4	2.465	
Calcium carbonate	$CaCO_3$	0.345	(Chalk)
Magnesium bromide	$MgBr_2$	0.217	

Traces of aluminum, boron, bromine, copper, fluorine, gold, iron, lithium, manganese, silica, etc.

Using lime as a reagent, the magnesium is precipitated as magnesium hydroxide. The magnesium hydroxide thus recovered forms the basis for the preparation of other commercial magnesium salts.

The uses of the principal products of the plant are listed below.

- Magnesium carbonates (U.S.P. and technical)
  - In salt—to facilitate free flowing.
  - In printing inks—as filler to fix colors and give opacity.
  - In paints and varnishes—as a filler and for fireproofing.
  - In rubber compounding
  - In metal enameling—to improve finishes.
  - In insecticides and fertilizers—as filler and for free flow.
  - In filtration—a clarifier
  - In cosmetics (talcum powders)
  - In pharmacy—antacid tablets, powders, prescriptions.
- Magnesium oxide light and heavy U.S.P.
  - Pharmaceutical—antacid tablets, powders, prescriptions.
- Magnesium oxide light and medium technical
  - Rubber compounding, pharmaceutical and general uses.
- Magnesium oxide and high purity carbonate
  - Electrical—fluorescent lighting and heating units.
- Magnesium hydroxide (dry and paste)
  - Pharmaceutical—milk of magnesia, citrate of magnesia, magnesia tablets, toothpastes, antacid tablets and powders.

Petroleum

Oil in San Mateo County was noted as early as 1865. On May 6 of that year the Mining and Scientific Press stated:

> We understand that oil has been discovered on Bell's ranch about 15 miles below Half Moon Bay where oil had previously been discovered on Purisima Creek.

Shortly thereafter additional attempts were made to produce oil from the area (Jenkins 1943). Gore (1923) stated that initial drilling

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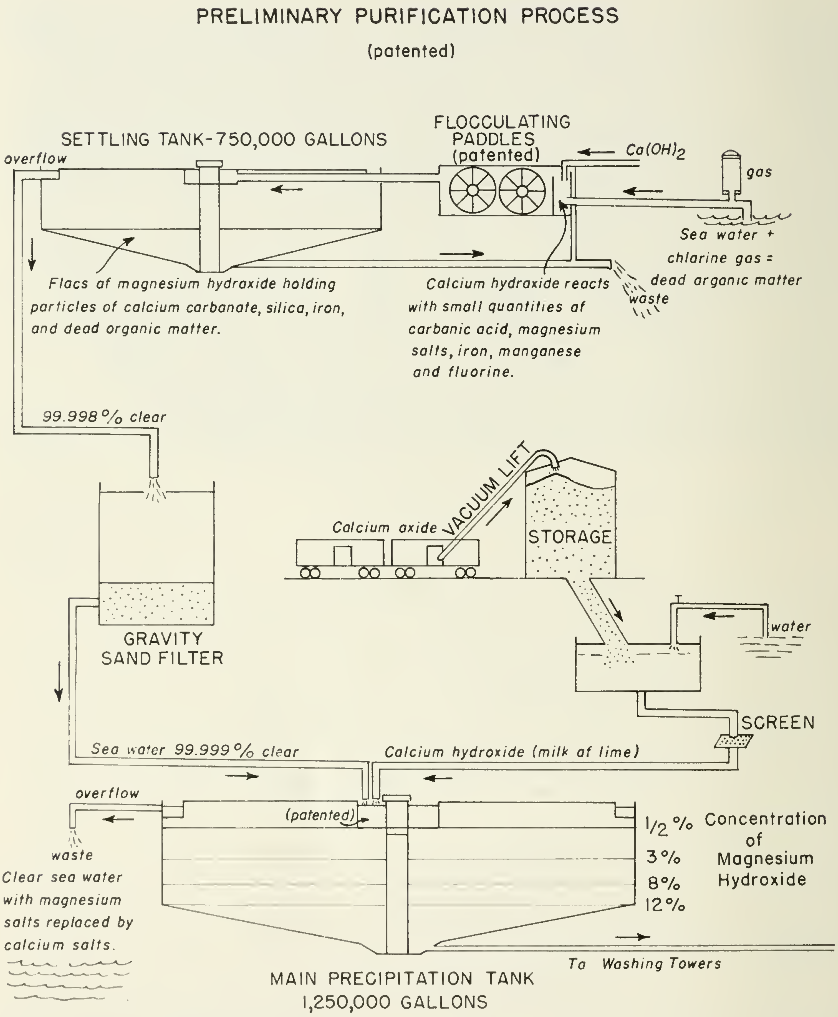
* From *Magnesium salts from the sea*, a brochure by Marine Magnesium Products Corporation.

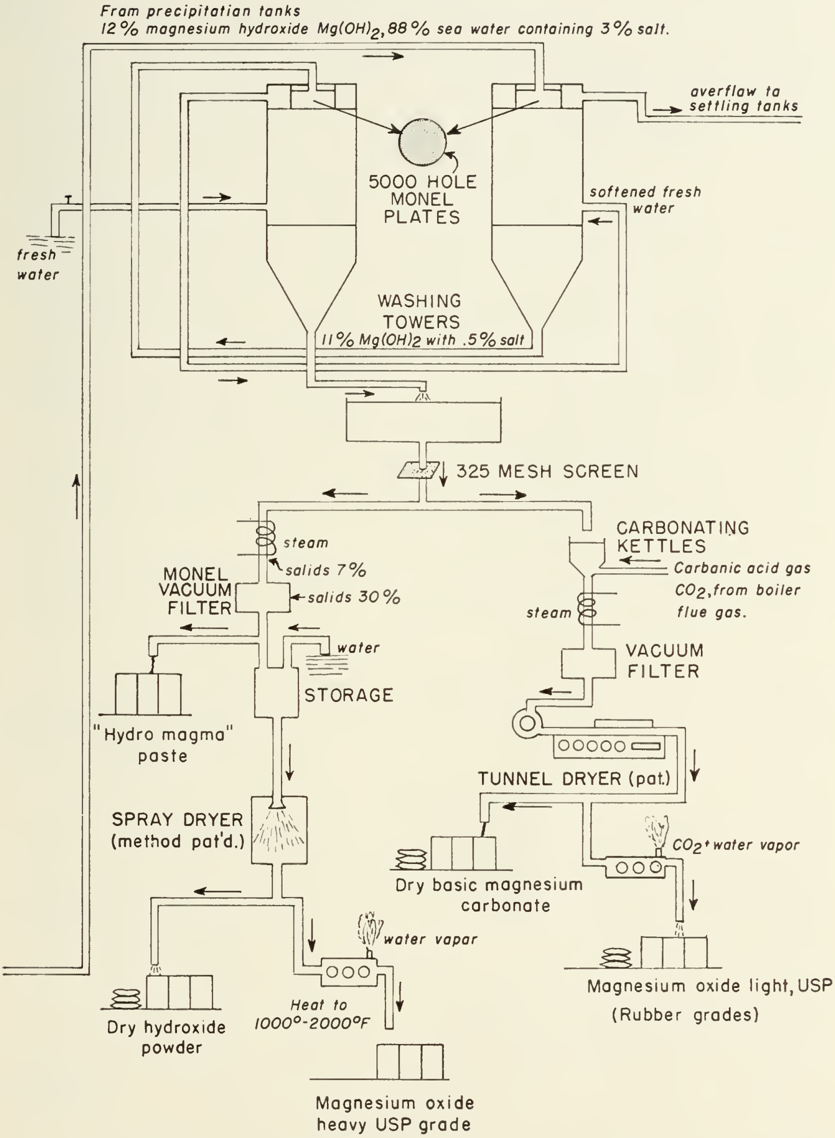

PRELIMINARY PURIFICATION PROCESS
(patented)
SETTLING TANK-750,000 GALLONS
overflow
FLOCCULATING PADDLES (patented)
Ca(OH)2
gas
Sea water + chlorine gas = dead organic matter
waste
Flocs of magnesium hydroxide holding particles of calcium carbonate, silica, iron, and dead organic matter.
Calcium hydroxide reacts with small quantities of carbonic acid, magnesium salts, iron, manganese and fluorine.
99.998 % clear
VACUUM LIFT
Calcium oxide
STORAGE
water
GRAVITY SAND FILTER
SCREEN
Sea water 99.999 % clear
Calcium hydroxide (milk of lime)
overflow
(patented)
waste
Clear sea water with magnesium salts replaced by calcium salts.
1/2 %
3 %
8 %
12 %
Concentration of Magnesium Hydroxide
To Washing Towers
MAIN PRECIPITATION TANK 1,250,000 GALLONS

RECOVERY OF MAGNESIUM SALTS

Figure 4

PURIFICATION OF PRECIPITATED MAGNESIUM HYDROXIDE

(patented)


From precipitation tanks
12% magnesium hydroxide $Mg(OH)_2$, 88% sea water containing 3% salt.
overflow to settling tanks
5000 HOLE MONEL PLATES
softened fresh water
fresh water
WASHING TOWERS
11% $Mg(OH)_2$ with .5% salt
325 MESH SCREEN
steam
solids 7%
MONEL VACUUM FILTER
solids 30%
water
STORAGE
"Hydro magma" paste
CARBONATING KETTLES
Carbonic acid gas CO_2, from boiler flue gas.
steam
VACUUM FILTER
TUNNEL DRYER (pat.)
SPRAY DRYER (method pat'd.)
Dry basic magnesium carbonate
CO_2 + water vapor
water vapor
Heat to 1000°-2000°F
Dry hydroxide powder
Magnesium oxide light, USP (Rubber grades)
Magnesium oxide heavy USP grade

FROM SEA WATER

Exploratory wells drilled for oil and gas in San Mateo County.

T.	R.	Sec.	B&M	Name of company and well	Date started	Date abandoned	Total depth (feet)	Geology at bottom
5S	5W	33	MD	Sage, W. A., No. 1	1–22	pre-1925	2,563	Miocene
6S	4W	17	MD	Continental Oil Company, Bianchi 1	8–50	11–50	5,850	Eocene
6S	5W	3	MD	Sage & Olsen	--------	pre–1925	930	Miocene
6S	5W	8	MD	(Shell Oil Co.) Cowell 1 Thompson & McNichles	2–27	1928	5,905	Miocene?
6S	5W	8	MD	(Shell Oil Co.) Cowell 2 Thompson & McNichles	4–28	1928	3,689	Miocene?
6S	5W	10	MD	McClintock, H. H., No. 1	4–24	pre–1925	517	Monterey
6S	5W	10	MD	Midstate Oil Co., No. 1	--------	----------	--------	
6S	5W	10	MD	Poso-Moon Oil Co., No. 1	9–22	pre–1925	830	Miocene
6S	5W	11	MD	Standard Oil Co., Std.-Rich.-Cafferata-Pimental No. 1	8–52	10–52	5,658	Eocene
6S	5W	15	MD	Elk Hills Pool Oil Co., No. 1	3–23	1935	1,114?	Miocene
6S	5W	15	MD	Sage, Olsen & Blalack, No. 1	8–22	pre–1925	2,100	Miocene?
6S	5W	15	MD	Skyline Oil & Refining Corp., No.1	4–28			
6S	5W	15	MD	Willard, E. T., 2	9–46	1948	2,422	Pliocene?
6S	5W	15	MD	Willard, E. T., 3	10–46	1946	2,001	Purisima
6S	5W	15	MD	Willard, E. T., 1	10–46	1946	1,896	Purisima
6S	5W	15	MD	Willard, E. T., Sarah Wilson 4	9–48	1948	1,610	
6S	5W	16	MD	Berger & Caglieri, No. 1	11–21	pre–1925	1,930	
6S	5W	16	MD	(Julian, C. C.) No. 4 . . . Thompson & McNichles	2–25	1925–26	1,800	Miocene?
6S	5W	16	MD	(Stratton Pet. Corp.) No. 1 Thompson & McNichles	8–29	----------	285	
6S	5W	17	MD	(A. & C. Co.) No. 1 Greater Santa Cruz Oil Co.	3–25—	1927	2,510	Miocene
6S	5W	17	MD	Wilshire Oil Co., Cowell 3	6–40	1940	1,954	Pliocene
6S	5W	20	MD	Elk Hills Pool Oil Co., No. 1	--------	pre–1925		
6S	5W	21	MD	Wilshire Oil Co., Inc., Cowell 1	8–37	1944	7,982	Miocene
6S	5W	21	MD	(Shell Oil Co.) Butts 1 Thompson & McNichles	1–28	1928	3,369	
6S	5W	21	MD	Thompson & McNichles, Butts 2				
6S	5W	22	MD	Berger & Caglieri, No. 2	7–22	pre–1925	1,765	
6S	5W	22	MD	Wilshire Oil Co., Inc., Cowell 2	9–38	1944	1,604	Pliocene
7S	4W	7	MD	Owsley, J. N., No. 1	--------	pre–1925	625	Miocene
7S	4W	7	MD	Owsley, J. N., No. 2	--------	pre–1925	275	Miocene
7S	4W	7	MD	Perkins well	--------	----------	1,100	
7S	4W	12	MD	Richfield Oil Corp., Isenberg 1	9–51	10–51	4,699	
7S	4W	16	MD	(La Honda Oilfields Assoc.) No. 1 La Honda Oil and Gas Co.	4–21	pre–1934	3,140	Miocene?
7S	4W	18	MD	Elk Hills Pool Oil Co., No. 1	6–25	pre–1925		
7S	4W	18	MD	(La Honda Oilfields Assoc.) No. 3 La Honda Oil & Gas Co.	6–25	----------	786	
7S	4W	20	MD	Elk Hills Pool Oil Co., No. 2	--------	pre–1925	436	Miocene
7S	4W	21	MD	McKinney & Ellis well	--------	pre–1925	288	Miocene?
7S	4W	21	MD	Northern Explor. Co., No. 1	1–23	pre–1925	340	Miocene
7S	4W	21	MD	Old Bell Well	--------	1905?	1,300	
7S	4W	5	MD	E. B. Ralston Ranch, Steele Bros. 1	3–26	1926	980	
7S	4W	26	MD	Jergins Oil Co., YMCA 1	6–50	6–50	2,510	
7S	4W	26	MD	Jergins Oil Co., YMCA 2	6–52	7–52	4,735	Eocene
7S	5W	10	MD	Texas Co., Ross 1	5–51	7–51	7,111	
7S	5W	13	MD	Bell and Burden, Inc., Riskin 1	7–51	9–51	4,500	Gas and oil shows 3740′-3954′.
7S	5W	13	MD	Sequoia Oil & Gas Co., Souza 1	7–27			
7S	5W	13	MD	Old O'Brien				
7S	5W	13	MD	Richfield Oil Corp., Lena Souza 1	7–44	1944	5,211	Miocene?
7S	5W	15	MD	San Mateo Pet Co.	-----	pre–1925	480	Miocene
7S	5W	15	MD	Unity Oil Co., No. 1	8–23	1925–26	600	Miocene?
7S	5W	20	MD	Walker, Fred C. & Albert Monyier, Walker, Monyier Caughey 1	10–46	1947	3,338	Pliocene
7S	5W	34	MD	Texas Co., Mattei Est. 1	6–51	8–51	5,813	
7S	5W	36	MD	Texas Co., Steele 1	9–51	1–52	8,025	Miocene
8S	3W	10	MD	Big Basin Paraffin Oil Co., No. 1-A	-----	pre–1925	360	Miocene
8S	3W	10	MD	Royer, Frank W., No. 1	5–23	1935	1,000	Miocene?
8S	4W	4	MD	Texas Co., Blomquist 1	7–50	9–50	4,957	Eocene sandstone and siltstone.
9S	4W	19	MD	Smuggler Divide Mining Co., No. 1	9–27	1930	900	

dated back to 1880, and that some of the wells reported an initial production of 50 barrels per day of 43° Baumé gravity oil from an average depth of 700 feet. Two deep wells drilled in 1950 were bottomed in Eocene sandstone (Oakeshott and others 1952).

A total of 49 wells have been drilled in the Half Moon Bay area to the end of 1950. Production has resulted from wells distributed through four separate producing localities, namely: Purisima, upper Purisima Creek, Tunitas Creek, and La Honda. Total production has been 41,330 barrels. No wells were producing in 1954.

The Half Moon Bay district was described by Crandall in 1943 and his remarks are summarized below.

> Sediments exposed in the district rest upon a basement complex of granodiorite, and comprise 26,000 feet of Cretaceous, Eocene, Oligocene, Miocene, and Pliocene strata. . . .
>
> Temblor Formation (Miocene). The Temblor formation consists of 200 to 2,000 ± feet of sandstones overlain by a series of argillaceous, calcareous, and organic shales, exceeding 400 feet in thickness, that carries foraminiferal zones markedly similar to those of the Rincon shale of Santa Barbara and Ventura Counties. The basal sandstones carry a Temblor megafauna and should constitute an excellent reservoir for petroleum, under proper conditions.
>
> Monterey Shale. The Monterey shale, possible source sediment for petroleum, overlies the Temblor shales, presumably in gradational contact, and consists essentially of organic, argillaceous, calcareous, and siliceous shales with minor sandy facies. These beds are best exposed along Butano Ridge east of Pescadero. . . .
>
> Volcanics. A series of basic intrusives and extrusives, consisting of diabase, basalt, and mud flows, agglomerates, and associated volcanic facies, has been mapped in and above the Miocene sediments in the easterly portion of the district. . . .

Vander Leck believed that the presence of basalt and diabase intrusives explained the presence of the high gravity oil in the overlying beds. He thought that the intrusives had caused destructive distillation of the oil, causing migration of the light fractions to the overlying beds and leaving a heavy residuum near the intrusives.

> Purisima Formation (Pliocene). The Purisima formation of the Mio-Pliocene is probably the most important sedimentary series in the district to consider in an evaluation of oil and gas possibilities. The series, which exceeds 9,500 feet in thickness in the vicinity of Purisima Creek, and thins rapidly to the north and south, contains adequate source sediments and reservoir rocks to afford important accumulations of petroleum on structure and, in addition, rests upon the organic Miocene sediments with the consequent probability of accumulation from that source. . . .
>
> The lower Purisima rests upon the Miocene and older rocks with pronounced local unconformity and consists essentially of medium- to coarse-grained gray to buff sandstone with minor beds of intercalated gray, brown, green, argillaceous, organic, and calcareous shales and siltstones together with some conglomerate. It overlaps the Miocene and older rocks and is, in turn, apparently overlapped by the middle Purisima in a few localities. A maximum thickness of some 4,500 feet is attained in the southerly portion of the basin; thinning is apparently rapid to the north and east. . . .
>
> The lower Purisima is impregnated with petroleum at many localities on the outcrop, and also in La Honda oil field, where small wells located on a westerly dipping monocline, yield high-gravity oil. . . .
>
> The middle Purisima consists essentially of diatomaceous, organic, calcareous, and argillaceous shales and siltstones with thin beds and lenses of fine- to medium-grained sandstone. The best exposures of the series are to be found on Pomponio Creek, in the southern portion of the district, where the thickness will average 2,600 feet. . . .
>
> The upper 2,500 feet of the middle Purisima has yielded the greater proportion of the petroleum produced in the area to date from wells drilled on the

> Purisima anticline and in the Purisima Creek and Tunitas Creek areas. The productive zones occur in thinly bedded sandstones and in sandy and fractured shales.
>
> The upper Purisima is a lithologic unit comprising medium- to coarse-grained sandstones, sandy shales, mudstones, and shales that rest with apparent conformity upon the middle Purisima shales. The contact has been placed, solely as a matter of convenience in mapping, at the base of the sandstones that overlie the middle Purisima shales. . . .
>
> The district is complicated by a number of folds and faults that trend generally northwest. Several of these mapped structural and stratigraphic features should be capable of trapping commercial quantities of petroleum. One of the dominant upwarps is the Purisima anticline, which extends from Pillar Point southwest for 11 miles to Tunitas Creek where it dies out in a westerly dipping monocline. The fold is asymmetric, is complicated by several faults, and has at least two local domes.

On October 12, 1955, an announcement was made that Union Oil Company well Richfield Costa #1 began to produce high-gravity oil. The well is located in NW$\frac{1}{4}$ of sec. 14, T. 8 S., R. 3 W., M.D., at an elevation of 1213 feet. Drilling began on September 6, 1955, and a total depth of 3804 feet was reached. Production of 41° B oil from a depth of 2206 feet was reported.

Salt

From the broad marshlands extending 12 miles southeastward from San Mateo, salt was produced by solar evaporation in 1901. Two centers of production sprang up, one at San Mateo and the other at Redwood City. Eventually one strong company emerged from each of these centers. Today, after a purchase and consolidation of properties, one company alone remains—the Leslie Salt Co.

The C. E. Whitney Company was formed about 1900 to recover salt on the 2790 acres of marsh land owned on the Pulgas Rancho south of San Mateo (Umland 1952). After the death of C. E. Whitney in 1903 the company was taken over by the Leslie Salt Refining Company. The refinery was located at 16th and S. Railroad Avenue, San Mateo. Details of the operation were presented by Huguenin and Costello (1917).

In 1924 the Leslie Salt Refining Company was consolidated with two companies operating in the East Bay (California Salt Company and Continental Salt and Chemical Company) under the name Leslie-California Salt Company. The operations at San Mateo were described by Senior (1929).

The Leslie-California Salt Company was consolidated with the Arden Salt in 1936 as the Leslie Salt Co. Owing to high taxes and the encroachment of urban development, salt making at San Mateo was discontinued in the same year. The plant was sold and the seat of company operations was transferred to Alvarado, across the bay.

The second center of solar evaporation in the county was located around the present Port of Redwood City. Here, in 1901, the Redwood City Salt Works began the construction of works for the production of salt under the supervision of G. J. Liguori.

The Greco Salt Company began production on Greco Island (Port of Redwood City) about 1905. The bay water was evaporated in vats. The crystallized salt was washed, crushed, and stacked by a portable machine. It was marketed without further treatment to the Alaska Packers. Production continued until 1920.

The West Shore Salt Company produced salt by solar evaporation from 1906 to 1911. During this period the crude salt was sold to the

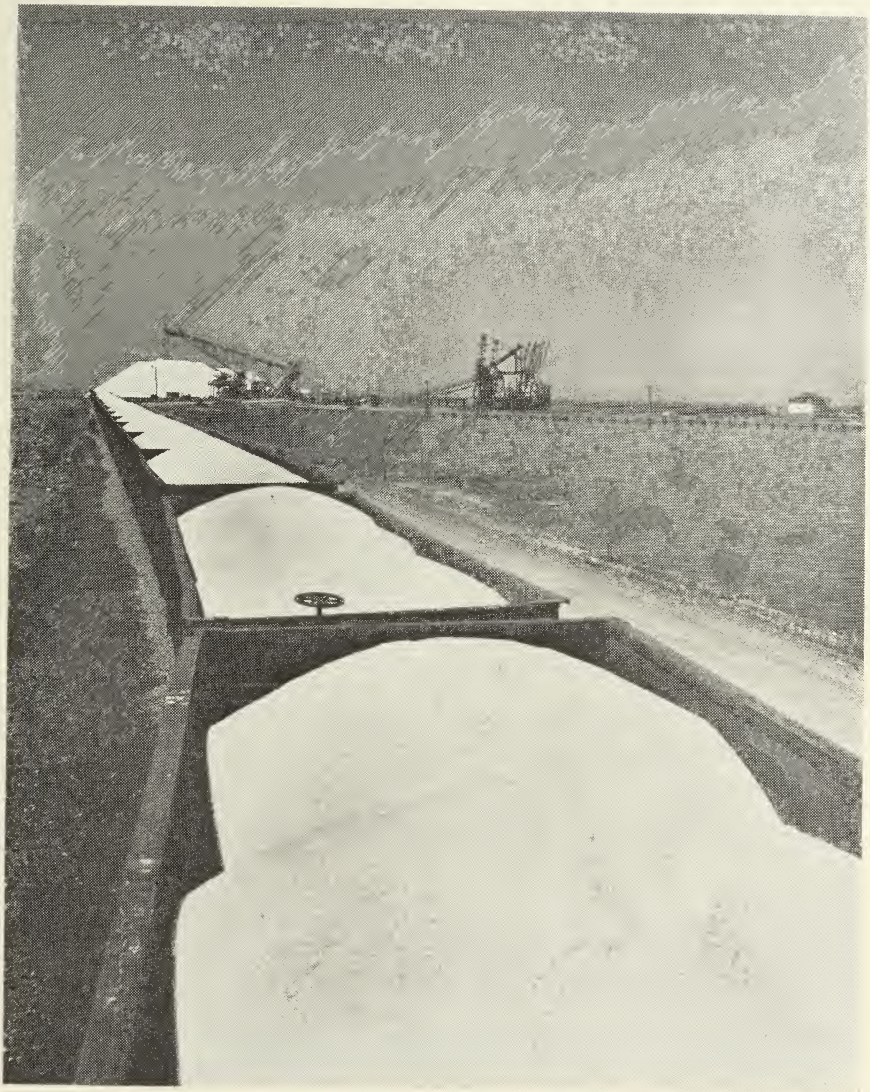


FIGURE 5. Rail connection, washing and stacking facilities for bulk salt at Redwood City. *Photo courtesy of Leslie Salt Company.*

San Francisco Salt Refining Company (a subsidiary of the Stauffer Chemical Company) whose plant was located in San Francisco.

About 1910 the Stauffer Chemical Company acquired the facilities of the Redwood City Salt Works, and in 1912 the same company purchased the properties of the West Shore Salt Company. Stauffer continued to operate the West Shore properties until 1926 when a three-year shutdown was effected. Production was resumed in 1929 and continued until 1942. The Redwood City salt properties of the Stauffer Chemical Company were sold to the Leslie Salt Co. in 1942.

The Leslie Terminal Company, a subsidiary of the Leslie Salt Co., built a deep water dock and bulk loading facilities at the Port of Redwood City in 1950. The salt ponds were reactivated and the production of crude salt for export was begun in 1951.

Leslie Terminal Company. Location: At the Port of Redwood City. On Harbor Boulevard 1 mile east of the Bayshore Highway; in secs. 16 and 17, T. 3 S., R. 5 W., M.D. Owner: Leslie Salt Co., 505 Beach Street, San Francisco; F. B. Bain, president.

The successful application of solar evaporation on a commercial scale requires the existence of a consistently high annual evaporation rate, a relatively low annual precipitation rate, extensive low use-value tidelands, and adjacent markets. These favorable factors are combined in the marshlands fringing the south end of San Francisco Bay.

Sea water is drawn into the receiving ponds through automatic intake gates during the period of high tide extending from April to October. The total mineral content of the sea water is at a maximum during this period, averaging about 3½ percent. About 2¾ percent of the total is sodium chloride (salt); the remainder consists of magnesium chloride, magnesium sulphate, calcium sulphate, potassium chloride, calcium carbonate, and bromides. Sea water has a density of 3.53° Baumé. The intake gates of wood or iron are placed in levees to take advantage of the driving force of the prevailing winds. Wooden gates treated with creosote do not corrode and have a life of many years although they are not as water-tight as the iron gates.

The concentrating ponds located south of Harbor Boulevard, are constructed in units which range in size from 60 to 300 acres. The amount of pumping between ponds is governed by the contour of the marshlands and every effort is made, therefore, to utilize gravity flow between ponds wherever possible. The shape of the concentrating ponds exhibits considerable irregularity depending upon the distribution of the sloughs. An attempt is made to avoid crossing sloughs when ponds and levees are constructed because of the softness of the slough bottoms. It is sometimes necessary to construct boundaries of sheet-piling along ponds bordering the sloughs. Many of the concentrating ponds, therefore, present a meandering outline.

The crystallizing ponds are placed inland from the sloughs and are rectangular in shape to permit easy harvesting. Since the movement of the "pickle" into the crystallizing ponds and subsequent removal of the brine must be made as quickly as possible, these ponds are filled and emptied by pumping. In the process of moving such huge quantities of pickle to the crystallizers, large low-head pumps ranging in capacity from 8,000 to 15,000 gallons per minute are used.

As the salt water progresses through the concentrating ponds the concentration of its mineral content increases as a result of solar evaporation until a density of 20° Baumé is reached. During the slow progress fine crystals of calcium carbonate, magnesium carbonate, iron carbonate, and calcium sulphate are continually formed. At 20° Baumé the concentrated brine is transferred to intermediate or lime ponds where calcium sulphate is deposited in large quantities. Here, through continued solar evaporation, the density of the brines increases to about 26° Baumé. Since sodium chloride begins to crystallize out of solution at a density of about 25° Baumé, a small quantity of salt is formed in the lime ponds. This salt is redissolved when weaker solutions are introduced into these ponds. At 26° Baumé the saturated salt solution or pickle is pumped into the crystallizing ponds where further solar evaporation causes deposition of the sodium chloride.

As the salt deposition continues more pickle is pumped into the crystallizers and this procedure continues until the brine in the crystallizing ponds attains a density of about 29° Baumé. At a concentration above 30° Baumé undesirable components such as magnesium chloride begin to crystallize. Since the bottoms of the crystallizing ponds are sloped toward the drain gates, the bittern or concentrated solution which remains is pumped out and transported by pipeline to a neighboring chemical company. Fresh pickle is again added to the crystallizer and the entire process is repeated until a layer of salt (sodium chloride) 4 to 6 inches thick has been deposited on the bottom of the crystallizing pond. The salt, which is very pure, becomes a mass of intergrown cubic crystals, which attain a considerable size. A cluster of such crystals on display in the museum of the California Division of Mines, Ferry Building, San Francisco, exhibits crystal units measuring 2 inches on an edge.

The harvesting of the salt crop has evolved through many stages and the item worthy of note in each successive stage is the constantly decreasing dependence of the operation upon manual labor. In the early days salt was hand-shoveled to wheelbarrows, later to dump carts in the ponds, and still later to pond conveyors. The modern method utilizes a Caterpillar-mounted harvesting machine. In this machine revolving picks break up the salt and deliver it to a drag-chain conveyor which loads a waiting train of bottom-dump cars at the rate of 125 tons per hour. The train consists of 12 to 14 wooden cars of 2-ton capacity, pulled by a gasoline or diesel engine running on a portable 30-gauge track. Once begun, harvesting the salt crop continues unceasingly until completed. Three shifts of 8 hours each, requiring three 9-man crews, are worked daily.

The salt is hauled to a central washing plant where the moving cars are bottom-dumped to a subsurface longitudinal receiving tank containing approximately 26° Baumé brine. Here the salt is scrubbed thoroughly to remove entrained clay, calcium sulphate crystals, and occluded bittern.

After preliminary cleaning, centrifugal pumps transfer the salt to the washing plant on the north side of Harbor Boulevard. Here, the salt is elevated to a drag washer with an inclined duplex screw-conveyor-dewaterer, then passes to a horizontal duplex log washer, is sluiced again with brine and passes through a final dewatering and washing drag conveyor. From the end of the drag conveyor the salt continues to be elevated and conveyed to the discharge point at the stockpile.

The stockpile is underlain by a tunnel conveyor leading to a fore and an aft ship-loading conveyor. The loading operation is highly mechanized for high speed loading so that a 12,000-ton ship can be loaded in 18 hours. The capacity of the Redwood City plant is 260,000 tons of salt per year.

Specialty Sands

Asphalt Aggregate Sand

Narrow strips of dune sand occupy the San Mateo shoreline at a number of localities. These dunes are mined on a small scale at Edgemar, Rockaway Beach and Pescadero. They were formerly mined also near Half Moon Bay. Large quantities of sand are necessary for the "mix" used in various types of road construction, and sand from the above localities has proved satisfactory in asphalt mixes.

Loosely consolidated sand in the upper part of the Merced formation has been used for the same purpose. Here the sand has been added to the products of crushed rock plants to supply the requirement of fines needed in asphalt mixes.

The usual specifications are that the sand be clean, hardgrained, moderately sharp, with a 3 percent maximum of earthy impurities.

Foundry Sand

Sand is an important raw material in the foundry industry. Foundries produce numerous types of metal castings and sand is required for the molds and cores. Local San Mateo County sands have been used in northern California since the earliest days of the foundry industry. Frequently these have been naturally bonded sands—mixtures of sand grains held together by clay in natural occurrence.

In 1925 the Industrial Mineral Products, Inc., was organized to produce and sell foundry sands. About 1927 the company erected a plant on Swift Avenue in South San Francisco and began utilizing local deposits which were described by Senior (1929) as follows:

> The company purchased a suitable plant site and deposit east of the City of South San Francisco on Swift Avenue, adjacent to the plant of the Pacific Coast Steel Company, and erected the most modern plant for the production of molding sands in the west. The main mill building contains 1750 square feet of floor space, with two additional buildings for the storage of crude material of 90,000 cubic feet capacity. The storage sheds are constructed in the shape of an L so that three different grades of crude material may be stored and conveyed to a central milling point.

In 1944 the plant was leased to Brumley-Donaldson Company, 75 Market Street, Oakland. The new company exploited two deposits in the county which were described by Wright in 1948:

> Millbrae Blended Molding Sand. "Millbrae" is a light molding sand produced by Brumley Donaldson Company from the hills west of Millbrae. Though introduced relatively recently, it is being widely used in foundries of the San Francisco Bay area. Extensive deposits of the base material were uncovered in the large excavations supplying fill for the San Francisco airport.
>
> The molding sand occurs as yellowish, poorly stratified material that appears to be an oxidized portion of the gray marine siltstone that underlies it. These beds, part of the Merced Pliocene formation, are moderately deformed. The yellow sandstone is softer than the gray underlying rocks. The contact between the two is sharp and irregular in detail, but is, in general, parallel with the topographic surface. Shell-rich layers and the more pronounced beds of the gray siltstone transect the contact. The layer, as now exposed in the higher parts of the ridge, ranges up to 20 feet in thickness and is covered with a 1- to 2-foot overburden of soil. It is stated to be similar to the Santa Barbara sand and to have a new sand permeability of about 12.
>
> The molding sand produced in this area is, of course, an insignificant fraction of the sand removed for fill. The Brumley-Donaldson Company, however, hope to continue to supply a Millbrae sand after the larger operation has ended. The sand is mined by power shovel and trucked to the South San Francisco

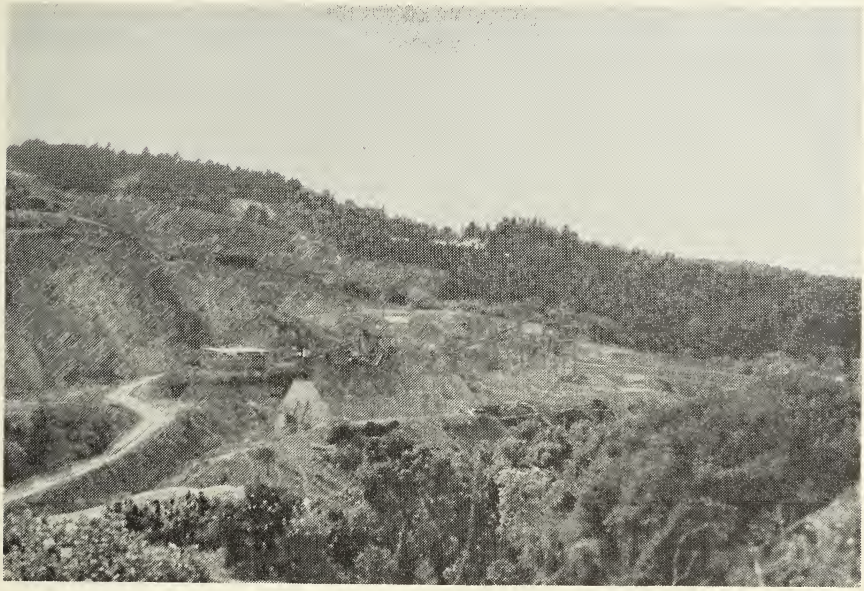


FIGURE 6. Skyline crushed limestone quarry and plant.

plant where it is fed through a hammer mill and a $\frac{1}{8}$-inch mesh screen. It is then blended with bentonite or fire clay to meet individual foundry specifications.

"(Millbrae blended) . . . has been found suitable for molding stove plates, light iron, and most non-ferrous metals except magnesium . . . (It) has fair refractory values which are increased by the addition of clay during processing. . . . It is a smooth working sand which gives a smooth finish to light work . . . but its properties of strength and durability can be substantially increased by mulling."

Table 29. Sieve analysis, Millbrae sand. (Analysis by D. L. Mason)

Sieve size	Percent retained	Cumulative percent
On 6	.8	.8
12	2.5	3.3
20	2.2	5.5
30	.9	6.4
40	.3	6.7
50	.6	7.3
70	.8	8.1
100	2.4	10.5
140	16.4	26.9
200	31.1	58.0
270	7.7	65.7
Pan	24.0	89.7
Clay	12.5	102.2

A.F.A. fineness number 155

San Francisco 440 Molding Sand. "San Francisco 440," a heavy molding sand, is obtained from excavations in the low hills between the city of South San Francisco and the San Francisco Bay shore and has been used in northern California since the early days of the foundry industry. In recent years it has been produced by the San Francisco office of Brumley-Donaldson Company.

The source of San Francisco 440 is a Quaternary alluvial deposit on a weathered surface of Franciscan rocks. This capping ranges in thickness to more than 20 feet. The sand is a light yellowish to reddish buff and is crudely stratified. It has, in general, a uniform grain size and composition, though some of the material appears slightly coarser. Small, rounded igneous and metamorphic pebbles are sparsely scattered throughout all of the exposures.

San Francisco 440 formerly was mined from a prominent hill immediately east and northeast of the present site of the Bethlehem steel plant. Much of the hill and almost all of its sand capping, however, have been removed for fill, and the sand is now obtained from a nearby excavation on Grand Avenue, northeast of the Swift and Company plant. Here a sand face from 15 to 20 feet high is exposed, and bedrock has not been encountered. The deposit is overlain by an earthy overburden 1 to 2 feet thick. In a cut immediately to the east, the sand overlaps an irregular Franciscan surface and has a crude horizontal stratification.

The sand is removed by power shovel in the rainless months and is trucked a short distance to a processing plant. Here it is dried by spreading and working with a bulldozer. It is then fed through a hammer mill and a ⅛-inch mesh screen and is stored in a shed sufficiently large for a winter's reserve.

Table 30. Sieve analysis, San Francisco 440 molding sand. (Analysis by D. L. Mason)

Sieve size	Percent retained	Cumulative percent
On 6	.6	.6
12	1.1	1.7
20	.8	2.5
30	.4	2.9
40	.7	3.6
50	4.3	7.9
70	15.6	23.5
100	29.7	53.2
140	11.1	64.3
200	3.1	67.4
270	1.7	69.1
Pan	7.9	77.0
Clay	22.0	99.0

A.F.A. fineness number 95

San Francisco 440, like Mission Red, is used principally in heavy iron and heavy brass casting. These sands are, therefore, comparable to Los Angeles Heavy and are not distributed in the southern California area.

"The actual permeability (of San Francisco 440) is around 50, which is fairly high, considering the high clay content. This clay content, approximately 22 percent, can be put to good advantage by using this sand as a blend with sharp sands. The permeability of the blended sands can be increased to as high as 150 by proper selection of the blend and by proper preparation—mulling and aeration.

"Good durability qualities and good finish on the castings can also be obtained by the addition of sea coral and pitch to the facing mixes."

Production continued until 1949. A decline in foundry production coupled with the increased uses of synthetic foundry sands caused a cessation of activity at that time. The plant has subsequently been dismantled.

Stone (Crushed)

Crushed stone has been one of the principal mineral products of the county throughout its history. Most of this material has been used in road construction although a considerable quantity of fill rock has been required to meet the needs of the post-World War II boom in the building construction industry. All rock types, igneous, sedimentary, and metamorphic, are included in the total production.

As a result of the growth of new communities and the expansion of the established residential areas in San Mateo County during the past 10 years, many formerly isolated quarry operators now find themselves hampered and restricted by the communities they helped to build. During its early stages the growing community needs large quantities of sound rock, easily accessible, and at competitive prices. Having achieved its growth, the established community wants peace and quiet, the freedom of its streets from heavy haulage and the accompanying traffic hazards.

Local civic organizations and the county planning commission have attempted to reconcile these conflicting forces by ordinances directed toward the establishing and operation of quarries.*

Chert

Small isolated outcrops of the radiolarian chert member of the Franciscan-Knoxville group are widely distributed. The principal outcrops are in the vicinity of Belmont where the chert is fractured, extremely contorted, and can be removed with a power shovel. Here, local quarries have produced chert for fill rock.

Conglomerate

Cretaceous conglomerate provides road rock in the vicinity of Pescadero. A Caterpillar bulldozer loosens the rock and pushes it over the quarry face. On the floor of the quarry it is transferred to trucks by a D-2 Caterpillar loader.

Granite

The Montara quartz diorite was first mapped by Lawson (1894) in considerable detail. He later (1914) described the rock as follows:

> The so-called "Montara granite" is a coarse-grained gray rock made up of quartz in abundance, plagioclase, orthoclase, and biotite or hornblende. One common facies of the mass contains both biotite and hornblende. In an earlier paper the writer stated that the rock is a hornblende-biotite granite, but subsequent examinations have shown that a facies of the mass which contains no hornblende but includes biotite is perhaps more widespread than that in which hornblende occurs either in association with biotite or alone. It was found also that by an increase in the proportion of plagioclase the rock at many places passes into quartz diorite, so that this designation is petrographically more correct for the mass as a whole, and the term granite is justified only by popular usage. Titanite and apatite are common accessories and titanite is locally abundant. The rock is more or less deeply weathered so that it is disintegrated in almost all its exposures except those on the shore and in the deeper canyons, where corrosion is rapid. The mass is at some places characterized by blotch-like inclusions of a dark, more basic rock and contains small dikes of aplite and pegmatite, two rocks that are in places intimately associated and locally include small crystals of garnet and magnetite. The rock shows occasionally a foliated or gneissic structure, which is clearly due to deformation, and evidences of deformation appear in the microscopic structure of the rock even where no foliation is apparent.

A small quantity of ''Montara granite'' has been quarried near the head of Montara Creek. This rock was used for building stone, curbing and crushed rock at Montara on the old Ocean Shore Railroad. The following analysis appeared in a report by Huguenin (1920):

---

* Ordinances numbers 960 and 961.

Montara Quartz-Grano-Diorite

SiO_2	58.78	58.69
Al_2O_3	18.35	18.29
Fe_2O_3	.95	.90
FeO	5.48	5.48
CaO	5.19	5.23
MgO	1.69	1.64
Na_2O	5.25	5.25
K_2O	2.21	2.21
H_2O	.84	.87
Li_2O	1.01	1.04
P_2O_5	.20	.30
	99.95	99.90

Some additional studies were made by Darrow (1951) who determined an average composition at the Devil's Slide area from thin sections as follows:

Mineral	Percentage
Oligoclase	50
Orthoclase	25
Quartz	20
Biotite	4
Sphene	1

He found "an increasing abundance of vein quartz in the higher peaks of Montara Mountain." Bodies of milky quartz are present which have been prospected for metals.

A petrographic description of quartz diorite collected in deep waters off the central California coast has been prepared by Chesterman (1952). The biotite-quartz diorite samples collected closely resemble the quartz diorite exposed at Montara Mountain.

Canadas (California Paving Company—Coast Rock Company). Location: About 2½ miles east of Half Moon Bay on the north side of state highway 105 in NW¼ sec. 22, T. 5 S., R. 5 W., M. D. Owner: Joe Canada, Route 1, Box 12, Half Moon Bay.

The biotite quartz diorite exposed in this locality is massive and fine-grained. Although the upper half of the quarry face has weathered to a tan color, the lower half of the face is fresh and tough. At the west end of the quarry the quartz diorite is in fault contact with Tertiary sandstone.

The quarry has been developed with two benches The uppermost bench is about 40 feet wide and 100 feet long with a face 100 feet high. The lower bench is about 150 feet wide and slopes toward the highway. The face is about 100 feet high.

The eastern edge of the upper bench is overlain by about 30 feet of angular terrace gravel of granitic origin. The gravel is capped by a cover of black soil about a foot thick.

Crushed stone and sand were the principal products of this quarry and the last production was made in 1951.

El Granada. Location: At the head of Santa Rosa Avenue, El Granada, about three quarters of a mile east of state highway 1 in NW¼ sec. 13, T. 5 S., R. 5 W., M. D. (projected). Owner: State of California.

The rock is friable, medium-grained biotite quartz diorite. It is tan colored from weathering of the ferromagnesian minerals and much of the quarry face is covered with a talus of granitic sand.

The quarry is semicircular in shape with a face over 200 feet high sloping westward and a floor width about 150 feet in diameter. The rock is used intermittently as road and fill rock.

Limestone

Calcite (calcium carbonate, $CaCO_3$) is the principal mineral component of limestone. Most limestones are impure and the chief impurities include dolomite (magnesium-calcium carbonate, $Mg,CaCO_3$); silica, SiO_2 (as quartz or chert); iron oxide, Fe_2O_3; clay (aluminum silicate); organic matter.

Limestone is extensively used in chemical and manufacturing industries, in cement, in agriculture, and in metallurgy. The production from San Mateo County, however, has been used mainly for road construction and as concrete aggregates in the building industry.

The original studies on limestone in San Mateo County (Lawson 1914) were made in the vicinity of Calera Valley about 13 miles south of San Francisco. The rock was designated Calera limestone and was defined as a member of the Cahil sandstone. The latter is the basal formation of the Franciscan group of rocks. The limestone occurs in discontinuous outcrops in San Mateo County extending from Rockaway Beach southeastward to Crystal Springs, a distance of about 11 miles. The limestone strikes northwestward and is associated with sandstone, chert, shale, serpentine, and volcanic rocks which lie in a sheared block of the San Andreas fault zone.

The deposits were recently studied in detail by Walker (1950) who stated in part:

> Individual masses of limestone are as much as a mile in length and range from 40 feet to a maximum of half a mile in width. The outcrop width does not everywhere represent the thickness of the limestone, for within individual masses the bedding is complexly folded and faulted. The thickness of the limestone is not uniform; at Rockaway quarry and at the Permanente quarries the thickness can be measured in hundreds of feet, whereas in other areas the thickness may be as little as 40 feet.
>
> On the San Francisco Peninsula the limestone apparently is in one stratigraphic zone which is divided lithologically into at least two units. The upper unit is light buff to gray and locally has been named the "Upper Light" limestone. The unit stratigraphically beneath the light limestone is dark blue gray to black and is referred to locally as the "Blue" limestone.
>
> Irregular joints and fractures, spaced from one-fourth inch to a foot apart, are characteristic of the Calera limestone throughout the length of the belt. Generally the "Blue" limestone shows greater deformation and more intense fracturing than the "Upper Light" limestone, though in the area between the Pilarcitos and San Andreas faults, both types of limestone are crushed and broken.
>
> Two possible explanations of the structural relationship of the Calera to the surrounding rocks are indicated by the faulted and sheared contacts between the Calera limestone and the surrounding sandstones and shales, and by the areal distribution of the limestone. Originally the Calera limestone may have been a continuous, or nearly continuous, unit interbedded in Franciscan-like rocks, or the lenticular limestone masses may all be fault slivers sheared into rocks of the Franciscan group. Evidence to solve this structural relationship is both obscure and contradictory; however, a fault relationship appears to be more plausible.
>
> The "Upper Light" limestone is light gray and contains numerous well-defined chert lenses and beds which form darker bands on weathered surfaces. Most of the limestone between the layers of chert is very finely crystalline and contains some foraminiferal remains. The beds, which range in thickness from 3 to 18 inches, have not been deformed as intensely as those of the "Blue" limestone; however, near faults the "Upper Light" limestone has been considerably dragfolded and crumpled.

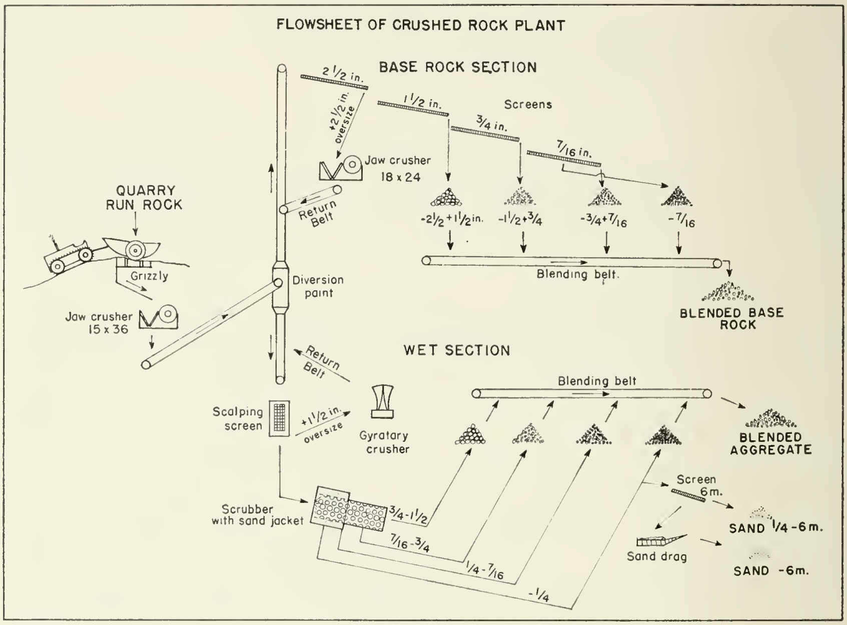

FLOWSHEET OF CRUSHED ROCK PLANT
BASE ROCK SECTION
2 1/2 in.
+2 1/2 in. oversize
1 1/2 in.
Screens
3/4 in.
7/16 in.
Jaw crusher 18 x 24
Return Belt
QUARRY RUN ROCK
Grizzly
Jaw crusher 15 x 36
Diversion point
-2 1/2 +1 1/2 in.
-1 1/2 +3/4
-3/4 +7/16
-7/16
Blending belt.
BLENDED BASE ROCK
WET SECTION
Return Belt
Blending belt
Scalping screen
+1 1/2 in. oversize
Gyratory crusher
BLENDED AGGREGATE
Screen 6 m.
Scrubber with sand jacket
3/4 - 1 1/2
7/16 - 3/4
1/4 - 7/16
-1/4
SAND 1/4 - 6 m.
Sand drag
SAND -6 m.

FIGURE 7.

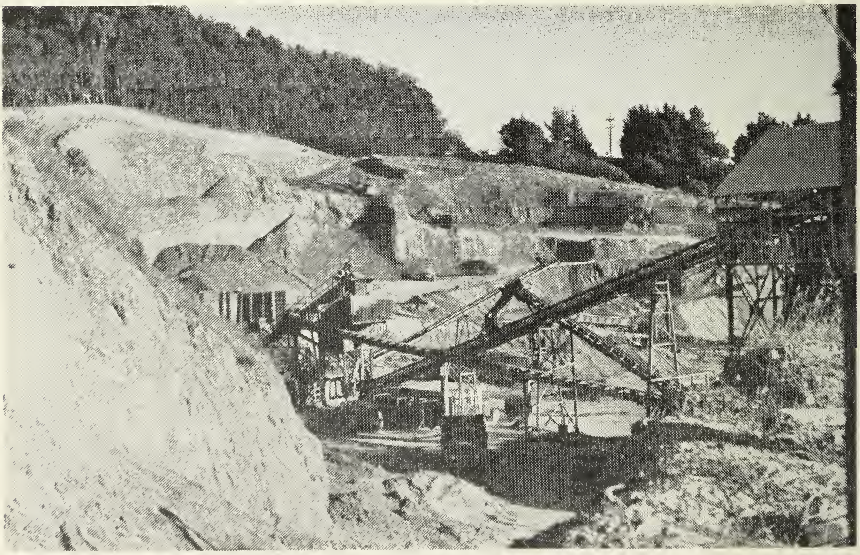


FIGURE 8. Crushed sandstone quarry and plant on west slope of Buri-Buri Ridge. Operated by Lowrie Paving Company.

> The "Blue" limestone has beds ranging in thickness from 1 inch to 8 inches, and the unit varies in lithology from the base to the top. Near the base finely crystalline limestone beds are intercalated with abundant chert lenses and layers. Upward the number of chert lenses diminish, and locally the top 15 or 20 feet is relatively free of siliceous material. The upper limestone beds in this sequence are medium to coarsely crystalline. Interbedded in the "Blue" limestone are layers of laminated tuffaceous debris a few inches to a few feet thick, and at many outcrops bedding-plane shearing has caused complex intermingling of tuffaceous fragments with fragments of oxidized and altered greenstone and sandstone. Weathered surfaces throughout the sequence are gray, whereas freshly broken surfaces are dark gray to black. A distinct petroleum-like odor is noticeable on freshly fractured surfaces, particularly in the upper part of the "Blue" limestone sequence. Locally, along bedding planes and near cross faults, the limestone is brecciated and the fragments are recemented by caliche and other carbonate material. In some places, incomplete recementation of the breccia has resulted in porous, spongelike masses of limestone. The "Blue" limestone is highly deformed and fractured and prominent drag folds occur near all but the smaller faults.
>
> The "Upper Light" limestone and the "Blue" limestone are very similar in chemical composition. Silica, in the form of chert lenses, is the most important impurity in both units; other adulterating materials are present in negligible quantities. The percentage of SiO_2 varies not only from outcrop to outcrop within the belt, but also from one stratigraphic horizon to another within the limestone units. Limestone beds between layers of chert have a calcium carbonate content as great as 97 percent. Small quantities of MgO, SiO_2, Al_2O_3, and Fe_2O_3 are the only impurities. The "Blue" limestone generally contains a higher ratio of $CaCO_3$ to SiO_2 than the "Upper Light" limestone. The purest beds are near the top of the "Blue" limestone where chert lenses are scarce or absent, and the $CaCO_3$ content approaches 97 percent of the rock analyzed.

An economic study of the limestone of the San Francisco region was made by Eckel (1933). He summarized the problem as follows:

> The entire question of commercial utilization of these Franciscan limestones depends, upon this matter of contained chert, not merely upon the amount of silica present in that form, but upon the way in which it is distributed in the limestone beds. For this reason each individual tract upon which it is proposed to quarry the Calera limestone should require special study and prospecting; it is impossible to take for granted that the conditions found in one set of outcrops will be the same (so far as working conditions are concerned) as those occurring a mile away. There are always beds of high-grade limestone in the Calera formation, but the question always is how much chert must be handled, to produce a ton of this high-grade merchantable stone.

The four limestone deposits described below have supplied road rock and aggregates intermittently for many years, for construction projects in the vicinity of San Mateo County.

California Aggregates (Ken Royce). Location: South of Rockaway Beach and about three-quarters of a mile southeast of state highway 1; near center of sec. 11, T. 4 S., R. 6 W., M.D. (projected). Ownership: Ken Royce Construction Equipment Company, 205 South Linden Avenue, South San Francisco.

Development of this deposit began in 1944. An analysis of the rock was reported by Logan (1947) as follows:

	Percent
SiO_2	5.1
Fe_2O_3	0.49
Al_2O_3	1.05
$CaCO_3$	91.7
$MgCO_3$	1.62
	99.96

The workings in 1954 consisted of a lower pit about 60 feet deep, 40 feet wide and a quarter of a mile long; and an upper circular pit about 65 feet deep and 500 feet in diameter.

Apparently both pits have been mined to their economic limit and no production has been made since 1952. During 1954 sales were being made from an accumulated stockpile.

The quarry rock was delivered to a Pioneer portable plant #C-646 with jaw crusher reduction to 12-inch size. Stationary equipment in an adjoining plant included a Telsmith jaw crusher, belts, screens, 4-foot Symons cone crusher, duplex rake classifier and bunkers. The plant products were crushed stone and base rock.

Hilltop. Location: West of lower Crystal Springs Lake, about 1¼ miles north of the junction of Skyline Boulevard and state highway 105; in sec. 11, T. 5 S., R. 5 W., M. D. (projected). Ownership: W. H. Torpey, et al.

This quarry, on the west slope of Cahill Ridge at an elevation of 1050 feet, exposes a series of thin limestone beds. The limestone outcrop is at least 150 feet wide and extends for a quarter of a mile north of the workings. The beds are buff-colored and weather to a light gray color. They vary in thickness from ¼ inch to 6 inches and are thoroughly sheared and extremely contorted. They are interbedded with lenses of black chert 1 to 3 inches thick, 1 inch to 1 foot apart vertically, and of variable length (1 foot to 6 feet, or longer). The chert lenses are staggered through the section in an indiscriminate manner. Both the limestone and the chert are cut by cross fractures subsequently filled with calcite. The entire section is covered by an overburden of dark brown soil varying from 5 to 10 feet deep. Near the main workings the overburden has been removed by a bulldozer.

The beds are exposed in two cuts. The face of the northermost cut is about 40 feet high and 270 feet long, while the floor is about 60 feet wide. The face is inclined about 75° westward. Here, a truck-loading tunnel of frame construction with four overhead loading gates has been constructed. The southernmost cut is about 40 feet high and 100 feet long.

This quarry was last operated in 1951 and was still idle in October 1954.

Marks Materials Inc. (Rockaway). Location: At Calera Hill, north of Rockaway Beach and west of state highway #1; in the west half of sec. 2, T. 4 S., R. 6 W., M.D. (projected). Owner: Ideal Cement Company, Redwood City; leased to Marks Materials Inc., Rockaway Beach.

This quarry produced substantial quantities of crushed stone between 1910 and 1919 when it was operated by the E. B. and A. L. Stone Company. Owing to increased freight rates during World War I the quarry was closed in April 1919. It lay dormant for 23 years. The production of concrete aggregate and ballast was resumed in 1942 and has continued to date. The present operator leased the property in 1953.

Calera Hill covers about 45 acres. It originally stood 337 feet above sea level and the surrounding lowlands of Calera Valley. Structurally, the hill is synclinal, the syncline plunging northwestward under the sea. The flanks of the syncline are bounded by faults.

An analysis of the limestone was reported by Logan (1947) as follows:

	Percentage
Calcium oxide ($CaCO_3$ equivalent 68.47%)	38.35
Magnesia (MgO)	0.34
Soluble iron oxide and alumina	1.78
Ignition loss	31.88
Insoluble (sand, silicates, etc.)	27.65
Water soluble alkalinity (as Na_2CO_3)	nil
	100.00

The quarry face is about 200 feet high and the top of the hill has been leveled. A D-8 bulldozer equipped with a hydraulic rooter loosens the rock on the hilltop and moves it to the quarry face where it falls to the quarry floor. Occasional light blasting is also necessary. A second bulldozer working on the quarry floor moves the broken rock to a grizzly.

Here the rock passes to a 28 by 36-inch Traylor jaw crusher making a reduction to minus 6-inch size. Thence by a 75-foot conveyor belt to the screen-house where the plus 3-inch fragments are directed to a 4-foot Telsmith gyrosphere for reduction and are returned to the screens. The plus 2-inch fragments pass to a 3-foot cone crusher and thence to a portable Cedar Rapids screening plant equipped with a roll crusher. The final rock products are: minus ½-inch, minus ¾-inch, minus 1½- and minus 2½-inch (crusher run base).

Production is at the rate of about 200 tons per hour and 12 men are employed. A hot-plant to make asphalt mix is being installed on the property. The adjoining Rockaway ready mix plant uses Marks products.

Skyline. Location: About half a mile west of the Crystal Springs Reservoir bridge in sec. 12, T. 5 S., R. 5 W., M.D., projected. Operator, Howard E. Marks, P.O. Box 278, Belmont, who acquired the lease about 1950.

The quarry is worked as a trench-cut about 100 feet wide running northwest for about 1000 feet with east and west faces. The west face is most active. Near the southern end of the west face Calera limestone is overlain by an overburden of weathered andesite ranging from 20 to 50 feet thick. The overburden is moved westward by a bulldozer before ''shooting down'' the limestone.

Near the longitudinal center of the trench the width of the trench narrows to 30 feet. Here the west face is 100 feet high while the east face is 30 feet high. The limestone beds are thin or lens-like and are intercalated with thin chert beds and lenses. The rocks have been extremely fractured and broken by movement along the San Andreas fault and dips in many different directions can be noted. Some vertical dips can be seen in the east face.

The west face continues northwestward for an additional 500 feet beyond the north end of the trench. Here the west face is worked in a series of benches.

The rock is mined by 10-cubic foot and 15-cubic foot capacity carryalls assisted by D-8 and D-6 bulldozers. After a short haul to the screenhouse grizzly, the rock drops to a 15 by 36-inch primary jaw crusher and is conveyed 50 feet to the diversion point. Here two options for further processing are possible and the rock may be directed either to (1.) the base rock plant, or (2.) the wet plant.

1. The base rock plant includes a 150-foot belt conveyor; a set of 4 by 8-foot Lippman screens making $2\frac{1}{2}$-inch, $1\frac{1}{2}$-inch, $\frac{3}{4}$-inch, and $\frac{7}{16}$-inch products which are stockpiled in line; and a return belt which conveys the plus $2\frac{1}{2}$-inch size to an 18 by 24-inch jaw crusher. The stockpiles are underlain by a blending belt connecting with a cross belt terminating on a lower level at the main base-rock stockpile.

2. The wet plant includes a 150-foot conveyor belt; a screen; a 3-foot gyratory crusher to reduce the $1\frac{1}{2}$ inch oversize which is returned to the feed screen; a 3 by 6-foot scrubber to wash the $1\frac{1}{2}$-inch undersize; screens $\frac{3}{4}$-inch, $\frac{7}{16}$-inch, $\frac{1}{4}$-inch, 10 mesh size, and 6 mesh size; and a sand drag to recover the minus 6 mesh product.

The washed products include: $1\frac{1}{2}$ by $\frac{3}{4}$-inch, $\frac{3}{4}$ by $\frac{7}{16}$-inch, $\frac{7}{16}$ by $\frac{1}{4}$-inch and $\frac{1}{4}$ inch by 10 mesh. These products may be blended as desired. Asphalt mix and ''black top'' are also made.

Production is about 300,000 tons per year; 15 men are employed.

Sandstone

Franciscan sandstone is widely distributed and various component members have been used. The hard metamorphosed sandstone member is dominant in the San Bruno Mountain area where it has been quarried at several localities. Current production is principally from Guadalupe Valley and Buri-Buri Ridge. The best rock usually lies at some distance below the surface. It is hard, tough, and requires blasting and crushing.

Vaqueros sandstone from a quarry about 2 miles north of Half Moon Bay was used for road rock.

Brisbane (Macco Construction Co.-Old Mission). Location: About $1\frac{1}{2}$ miles west of Brisbane in Guadalupe Valley; in SW$\frac{1}{4}$ sec. 9, T. 3 S., R. 5 W., M.D. (projected). Owner: Crocker Estate Co., 620 Market Street, San Francisco; leased to Pacific Coast Aggregates Inc., 400 Alabama Street, San Francisco.

The company leased the property in 1950. The semicircular quarry is at the head of a small ravine swinging southward off Guadalupe Valley. Near the eastern edge of the quarry the sandstone is in fractured thin beds alternating with shale. Dip is 45° east. At the center of the quarry about 10 feet of overburden tops the weathered brown arkosic Franciscan sandstone. At a depth of about 50 feet the rock grades into massive blue sandstone. The latter continues through an intermediate bench to the quarry floor. The total height of the face is about 200 feet.

In blasting, holes ranging from $2\frac{1}{2}$ to $1\frac{3}{8}$ inches in diameter and 24 feet long are drilled into the toe of the quarry. The holes are sprung with 60 percent Gelamite and shot with 4 percent Hercamite. The broken rock is loaded by $2\frac{1}{2}$-yard Northwest diesel shovel to 15-ton rock-bed end-dump autocar trucks and hauled about a quarter of a mile to the crushing plant.

The company has redesigned the plant to produce multiple products. Included in the flowsheet are a 48 by 72-inch primary jawcrusher, and tertiary gyratory crushers. Dry screening produces the following products: minus $2\frac{1}{2}$-inch, plus $1\frac{1}{2}$-inch; minus $1\frac{1}{2}$-inch, plus 1-inch; minus 1-inch, plus $\frac{3}{8}$ inch; and minus $\frac{3}{8}$-inch.

During normal operation the quarry employs 24 men working one 8-hour shift. Production is rated at 2400 tons per day. A ''black-top'' asphalt plant has also been installed on the property. This plant is fed by a pug mill with a rated capacity of 500 tons per hour.

Stone (Miscellaneous)

Many rock types that are unsuitable for concrete aggregate or highway base rock can be used for fill-rock. Large quantities of fill-rock are currently in demand in the construction industry, especially in new housing subdivisions, airports and other industrial projects. Most of these rock types can be readily quarried with a power shovel or carryall. No further processing is necessary and the fill-rock is trucked immediately to its destination.

Altered lava flows rendered friable by fracturing have been quarried near Belmont, Woodside and Rockaway Beach.

Soft sandstone, shale, and conglomerate of the Merced formation have been extensively used from a quarry west of Millbrae.

Many of the components of the Franciscan-Knoxville group of rocks have been fractured and rendered plastic or friable by subsequent alteration. Soft shale, friable chert, silica-carbonate rock, lavas and serpentine are included in this group. Such rocks often occur in close proximity to each other in the same quarry. They have been used from quarries near Bayshore, South San Francisco and Belmont.

Each quarry is described in the tabulated list at the end of this report.

Processing of Imported Gypsum *

Kaiser Gypsum Division, Redwood City Plant. The Redwood City plant of the Kaiser Gypsum Division, Kaiser Industries, Inc., manufactures gypsum board and lath products for the Bay area and the northern California market. Ernest Schaper is the plant superintendent, the superintendent of the wallboard plant is Lawrence E. Hays, and Wallace C. Riddell is director of research. Built by the Pacific Portland Cement Company in 1941, the plant was taken over by the Kaiser interests in October 1949. It is located at the Port of Redwood City where crude gypsum is brought in Kaiser ships from the San Marcos Island deposit and stockpiled near the plant.

The crude gypsum as received at the wallboard plant is 2 to 3 inches in size and averages 96½ percent gypsum. Trucks deliver it from the stockpile to a hopper from which it is fed to a jaw crusher that reduces it to half-inch size. The former operator calcined a mixture of natural and synthetic gypsum, but this practice has been abandoned. It is believed that difficulty encountered in calcining the synthetic material may have been caused by a coating of magnesium hydroxide.

Calcining is accomplished with three number 50 Raymond Imp kiln mills driven at 1850 rpm by 50- and 60-horse-power motors. The temperature of the furnace gases is 1400° F., and the stucco is withdrawn from the mills at 360° to 410° F. and 90 to 95 percent minus 100 mesh. Stucco is stored in cylindrical steel storage bins.

Stucco is withdrawn from the bins with drag conveyors, passed through a revolving half-inch screen to remove foreign matter, and brought to the mixing platform over the head of the Ehrsam board machine. Carefully measured amounts of additives are introduced into the screw conveyor with Gump feeders located on this platform. An

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* Quoted verbatim from Ver Planck, 1952, p. 102. *Ed. Note:* The plant was destroyed by fire in 1955.

Ehrsam type pin mixer is used to mix the dry ingredients with water. The Ehrsam board machine is provided with guides placed at intervals to keep the board in position. Talc powder is put on the top surface of the board to facilitate later handling. The switches that control the cut-off knife, transfer belts, and loading ramp are actuated by fingers that contact the lengths of board.

The Coe drier has six decks and is divided into three sections. Heat is provided by steam coils in the first and second sections and by gas burners in the air intakes to the second and third sections. The temperature in the first section is from 320° to about 350° F., about 360° F. in the second, and 250° F. in the third. Finished wallboard and lath are removed from the drier, inspected closely for quality defects, placed face to face; and the ends are sealed with paper tape. Then the bundles are placed in the warehouse or stacked in box cars for shipment.

At present the plant is operating 24 hours a day, 7 days a week, at a capacity that has been increased nearly 50 percent during the past year.

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TABULATION OF SAN MATEO COUNTY MINERAL DEPOSITS

The following table lists San Mateo County mineral deposits in alphabetical order by commodity. The number in the first column refers to the location on the county map, plate 5, in pocket.

The references given in the *Remarks* column refer to the bibliography accompanying this report. Only the last name of the author is given. The first number following the author's name is the abbreviated date of publication as given in the bibliography; the second number, that following the colon, is the page reference.

BITUMINOUS ROCK

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Hooper		8	8S	3W	MD	Some rock used for private road work pre-1919. (Huguenin and Castello 20:169; Senior 29:247).

CEMENT

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Ideal Cement Co. (Pacific Portland Cement Co.)	P.O. Box 669, Redwood City	9,10, 11,12, 13,14, 15,16, et al	4S	4W	MD	Built as a 2 kiln unit in 1924. Expanded, adding 2 kilns in 1927. Continued improvements to date. Purchased by Ideal in 1952. Uses oyster shells from San Francisco Bay as source of lime, bay mud as source of alumina and silica. (Senior 29:247-251; herein).

CLAY AND CERAMIC PLANTS

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Baden Brick Co.		At Snug Harbor $1\frac{1}{2}$ miles east of So. San Francisco				Made common and repressed bricks from a local, light-yellow, gritty clay. Plant dismantled many years ago. (Aubury 06:255).
	Steiger Terra Cotta and Pottery Works		At Snug Harbor $1\frac{1}{2}$ miles east of So. San Francisco				Incorporated in 1898. Used local and Amador County clays and red shale in pressed brick and sewer pipe. Plant burned in 1917. (Aubury 06:228; Huguenin and Castello 20:172; Boalich and others 20:95).
	West Coast Porcelain Mfrs.		Near Millbrae station				Manufactured vitreous sanitary porcelain from imported raw materials. (Dietrich 28:218-16).

LIMESTONE - SHELLS

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
1	Ideal Cement Co.	Ideal Cement Co., P.O. Box 669, Redwood City	11,12 (?)	4S	4W	MD (proj.)	Oyster shell beds used as a source of lime for cement. (Senior 29:247-251; herein.)

MAGNESIUM SALTS

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
2	Marine Magnesia Products Division, Merck & Co., Inc. (Marine Magnesium Products Company--Marine Chemical Company)	E. Grand Avenue, So. San Francisco	S½23	3S	5W	MD	At Point San Bruno. Production of magnesium oxide, hydroxide, and carbonate from sea water. (Senior 29:251; herein).

MERCURY

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
3	Emerald Lake	Homes by Sterling; leased to H.B. Piggott, 1057 Howard St., San Francisco	W½36	5S	4W	MD (proj.)	Mercury minerals reported by Rogers in 1911. Evidence of subsequent prospecting. Active prospecting in spring 1955. (Whitney 65:71; Rogers 11:48; Bradley 18:149; herein.)

SALT

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Greco Salt Co.	Leslie Salt Co., 505 Beach St., San Francisco	9(?)	5S	3W	MD	Supplied crude salt to Alaska Packers pre 1920. (Huguenin and Castello 20:174; 29:252; herein).
4	Leslie Terminal Co. (Leslie-California Salt Refining Co.--Leslie Salt Refining Co.)	Leslie Salt Co., 505 Beach St., San Francisco	6,7, 15,16, E$\frac{1}{2}$17, NW$\frac{1}{4}$17 et al	5S	3W	MD	A consolidation of all solar evaporation facilities on the west side of San Francisco Bay. Crude salt is produced from bay water; washed and screened for bulk export by water. (Huguenin and Castello 20:174-177; Senior 29:253-54; herein).
	Redwood City Salt Works						See Stauffer Chemical Co.
	San Francisco Salt Refining Co. (West Shore Salt Co.--Redwood City Salt Works)						See Stauffer Chemical Co.
	Stauffer Chemical Co.						See Leslie Terminal Co.
	Westshore Salt Co.						See Stauffer Chemical Co.
	Whitney, C.E. Co.						See Leslie Terminal Co.

STONE (CRUSHED) - CHERT

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Byrnes	City and County of San Francisco					Blue chert used on roads. (Huguenin and Castello 24:177; Senior 29:256).
5	Casey (Laurel Creek)	San Mateo Jr. College	NE$\frac{1}{4}$17	4S	4W	MD (proj.)	West side, San Mateo Point. Crumpled and contorted, chocolate brown, thin bedded chert alternating with shale. Face 25 feet high, 120 feet long; floor 75 feet wide. Probably used for road rock and fill. Intermittent activity. (Aubury 06:322; Huguenin and Castello 20: Senior 29:257).
6	Middle Road		SE$\frac{1}{4}$3	5S	4W	MD (proj.)	Belmont. Contorted, friable chert and shale of Franciscan formation. Manganese stains. Face 50 feet high, 25 feet long. Intermittent activity.
7	South Road	L.C. Smith Co., San Mateo	NE$\frac{1}{4}$ 10(?)	5S	4W	MD (proj.)	Belmont. Contorted, friable multicolored Franciscan chert and interbedded shale. Three 20-foot benches, quarter mile long. Inactive.
	Spilvalo and Johnson						Chert; Belmont. (Aubury 06:323; Huguenin and Castello 20:179).

STONE (CRUSHED) - CONGLOMERATE

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
8	Archibald (Shoreland)	J.O. Archibald, Redwood City	SE$\frac{1}{4}$9	8S	5W	MD (proj.)	About 1 mile southwest of Pescadero. Quarry in cretaceous conglomerate; some sandstone and shale. Semicircular face 100 feet high; diameter floor 75 feet. Intermittent activity.

STONE (CRUSHED) - GRANITE

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
9	Canadas	Joe Canada, Rt. 1, Box 12, Half Moon Bay	NW¼ 22	5S	5W	MD	Quartz diorite quarry worked for many years as a source of crushed rock. (Herein).
	California Paving Co.						See Canadas.
	Coast Rock Co.						See Canadas.
10	El Granada	State of California	NW¼ 13	5S	5W	MD (proj.)	Friable, weathered quartz diorite used for road and fill rock . (Herein).
	Irwin						Used locally at Montara for building stone, curbing and crushed rock. (Huguenin and Castello 20:173; Senior 29: 251).
11	Miguel	Miguel, Half Moon Bay					Friable, weathered quartz-diorite; used for road rock and fill rock.

STONE (CRUSHED) - LIMESTONE

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
12	California Aggregates	Ken Royce Construction Equipment Co., 205 So. Linden Ave., So. San Francisco	11	4S	6W	MD (proj.)	Limestone for crushed rock. Produced from 1944 to 1952. Sales from stockpile during 1954. (Walker 50:4,7; herein)
13	Hilltop	W.H. Torpey et al.	11	5S	5W	MD (proj.)	Limestone with interbedded chert. Used for crushed rock. Last operated in 1951. (Walker 50:4,7; herein).
	Ken Royce, Inc.						See California Aggregates.
14	Marks Materials (Rockaway Quarry)	Ideal Cement Co., leased to Marks Materials, Rockaway Beach	2	4S	6W	MD (proj.)	One of the oldest quarries in the county. Limestone for crushed rock. Operated 1910-19, idle 23 years, resumed operation 1942. Present operator leased property in 1953. (Huguenin and Castello 20:178; Eckel 33:354; Kelley 33:362; Walker 50:5,7; herein).
	Rockaway Quarry						See Marks Materials.
	Rockaway Quarry, Inc.	Harry Fishbein, Mori Point Road, Rockaway Beach	2	4S	4W	MD	Operated Rockaway Quarry pre-1953. Now producing ready-mix concrete. Purchase rock from Marks Materials.
	Skyline Materials Inc. (Skyline Quarry)	City and County of San Francisco; leased to Skyline Materials Inc. P.O. Box 278, Belmont	12	5S	5W	MD (proj.)	Production of limestone for crushed rock from a limestone lens in Franciscan formation. (Walker 50:7; herein).
	Skyline Quarry						See Skyline Materials, Inc.

STONE (CRUSHED) - SANDSTONE

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
16	Brisbane (Pacific Coast Aggregates Inc., - Macco-Brisbane Rock Co.)	Crocker Estate Co., leased to Pacific Coast Aggregates Inc., 400 Alabama St., San Francisco	SW$\frac{1}{4}$9	3S	5W	MD (proj.)	An old quarry at head of Guadalupe Valley in Franciscan sandstone leased by PCA in 1950. Upper 100-ft. face shows weathered brown sandstone grading into blue metamorphosed sandstone. Lower 100-foot face all blue. Shot and diesel shovel-loaded to truck hauling to crushing plant. Three-stage crushing and screening plant makes five products from $2\frac{1}{2}$ inch to pan. Production, 2400 tons per day; employs 40 men on two-shift per day.
17	Causeway	Crocker Estate Co., leased to Guy F. Atkinson Co., 10 W. Orange Ave., South San Francisco	NE$\frac{1}{4}$9	3S	5W	MD (proj.)	Opened new quarry north of Brisbane, west of highway, in Franciscan sandstone in Sept. 1954. Hauling fill rock for new Bayshore cutoff through tidelands. Shovel mining using 5 yard Bucyrus-Erie delivering to 20 yard Euclid dump trucks. Drill and shoot 30 foot vertical holes as needed using Joy unit. Production 13,000 yds. per day; 2-7 hr. shifts; contract 2,000,000 yards.
18	Daly's		NW$\frac{1}{4}$6	3S	5W	MD (proj.)	At Welling and Brunswick Avenues. Franciscan sandstone. Three 20-foot benches and one 125-foot ± face. Formerly used for railroad ballast by Market Street Railway. Inactive. (Aubury 06:323; Huguenin & Castello 20:177; Senior 29:257).
	Easley & Brassy						See Sanitary Fill and Southern Pacific.
19	Edgewood Road	H. Morton; leased to McCammon-Wunderlich, Palo Alto	NE$\frac{1}{4}$27	5S	4W	MD (proj.)	Tough Franciscan sandstone (graywacke). Mining with Caterpillar D-8 bulldozer and rooter; frontend loader and rooter. To grizzly, crusher, screens and bins. Products $2\frac{1}{2}$ inch and $1\frac{1}{2}$ inch rock. Production 1400 yards per day; employs 8 to 10 men.

STONE (CRUSHED) - SANDSTONE (CONT.)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
20	Golden West (Piombo Construction Co. - Ratteree Bros.)	California Pacific Title Insurance Co., leased to Piombo Construction Co.	W½4	3S	5W	MD (proj.)	South of Cow Palace, Bayshore. An old quarry in Franciscan sandstone. Worked to property line. Face 200 feet high, beds dip east 50° ±. Not operated during past 4 years. Old relic plant, machinery removed. Inactive. (Senior 29:256).
21	Healy-Tibbitts	Healy-Tibbitts Construction Co.	NW¼10	3S	5W	MD (proj.)	North of Brisbane, east of highway. Franciscan sandstone and shale. Dips 30-45° east. One 20-foot and one 40-foot bench. Alternating sandstone and shale in upper bench; massive sandstone in lower bench. Inactive.
22	Holy Cross	Holy Cross Cemetery, Colma	(?) NW¼17	3S	5W	MD (proj.)	Hillside Avenue, Colma. Two adjacent cuts in Franciscan sandstone. Faces 100 feet high, 50 feet across. Gyratory crusher, rusted elevator, sheet screens on premises Inactive 5± years.
	Lowrie Paving Co.						See W.P.A.
	Morton						See Edgewood Road.
	Pacific Coast Aggregates, Inc.						See Brisbane.
	Ratteree Bros.						See Golden West.
23	San Mateo Development Co.	Crocker First National Bank, San Francisco	SW¼30	4S	4W	MD (proj.)	On Highway 105, 2 miles west of San Mateo. An old quarry in Franciscan massive sandstone and thin interbedded shale. Face 150 feet high; 125 feet across. Worked to property line. Inactive.
24	San Mateo Development Co.	Crocker First National Bank, San Francisco	W½31	4S	4W	MD (proj.)	Half a mile westward from #23 a second cut with 200-foot face and 150 feet across. Sandstone and shale. Eight 10x10x15-foot wooden bunkers remain. Idle.

STONE (CRUSHED) - SANDSTONE (CONT.)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
25	Southern Pacific	Southern Pacific Co., 65 Market St., San Francisco	NW¼10	3S	5W	MD (proj.)	Franciscan sandstone and shale dipping 30° eastward. Two 20-foot benches, ¼ mile long. Worked by Easley and Brassy for fill rock. Idle.
26	Vasquez	E. Hester, H. Mansfield, 728 Arguello Blvd., Redwood City	SE¼17	5S	5W	MD (proj.)	North of Half Moon Bay, on Frenchman's Creek. Arkosic Vaqueros sandstone. Old bunkers. Inactive. (Huguenin & Castello 20:179).
	Whipple Road						See Edgewood Road.
27	W.P.A.	City and County of San Francisco; leased to Lowrie Paving Co.	SE¼16	4S	5W	MD (proj.)	Old quarry near Skyline and Millbrae Avenue., in Franciscan sandstone, reactivated in February 1953. Weathered brown sandstone to 100± feet. Tough blue-gray sandstone to 150± feet. Five 30-foot benches. Bulldozer works weathered rock, pushing it over bank to shovels for fill rock. Shovels mine blue rock, haul to screening plant. Jaw, gyratory, Symons crushers; screens, duplex sand drag, mud pond. Road rock and asphalt rock, sand fines (mud).

STONE (CRUSHED) - MISCELLANEOUS

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	A and B						See Canada Road (North and South)
28	Canada Road (North)	Peter Sorenson, 927 Arguello Blvd., Redwood City	E½34	5S	4W	MD (proj.)	Greenstone and greenstone altered to red rock. About 2 miles northwest of Woodside. Fill rock. Inactive.
29	Canada Road (South) (Woodside-Holt)	Tex Donovan, P.O. Box 381, Redwood City	E½34	5S	4W	MD (proj.)	About 2 miles northwest of Woodside. Greenstone and greenstone altered to red rock and rich red soil. Suitable for fill rock. Maximum face, 150± ft. Mined with Allis-Chalmers HD-5 front end loader. Worked since 1920. Active. (Senior 29:257).
	Donovan, Tex						See Canada Road (South).
	Gardner						Red rock (Aubury 06:323; Huguenin and Castello 20:177; Senior 29:257).
	Hildebrand		NE¼14	7S	4W	MD	North side of La Honda. Quarry absorbed in widening of highway. (Senior 29:257).
	Holt						See Canadas Road.
30	Kavanaugh	C.I. Kavanaugh, 1589 Bay Road, E. Palo Alto	SW¼19	3S	6W	MD (proj.)	Altered basalt. Fill rock. Intermittently active.
31	Macco-Morrison Knudson Construction Co.	Highland Builders Inc.	NW¼9	4S	5W	MD (proj.)	West of Lomita Park, Millbrae. Extensive quarry in Merced sandstone shale and conglomerate. Provided 4,700,000 cu. yds. fill for San Francisco airport, 1946-47. Mined with bulldozer, four diesel shovels, three electric shovels. In 1954-55 area is being graded for housing development.
32	North Road	L.C. Smith	SW¼3	5S	4W	MD (proj.)	New quarry in altered basalt. One 12-foot bench and one 25-foot bench; mined with a 2-yard Northwest diesel shovel. Trucked to Parkside Tract for use as fill rock. Active '54.

STONE (CRUSHED) - MISCELLANEOUS

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	Piombo Construction Co.						See Tyson.
33	Sanitary Fill	Easley and Brassy, operator, 55 New Montgomery St., San Fransicso	NW3	3S	5W	MD	Northeast of Bayshore. Franciscan rocks. Sandstone, multicolored, steeply dipping chert and shale, altered basalt. Some of chert is hydrothermally altered and manganese stained. Numerous benches. Shovel-loaded to trucks and used as a cover for adjacent garbage dumps. Worked since 1932; production 1,000 yards per day.
	Sorenson, Peter						See Canadas Road (North).
34	South S.F. Land and Improvement Co.	South S.F. Land and Improvement Co.	NE$\frac{1}{4}$22	3S	5W	MD (proj.)	Varied rocks of Franciscan formation used for fill at San Francisco airport etc. and now almost levelled for industrial sites. Inactive.
35	Tyson	Tyson & Alford; operated by Piombo Construction Co., 1571 Turk St., San Francisco	SW$\frac{1}{4}$9	5S	4W	MD (proj.)	Belmont. Stripping off hilltop in 10-foot benches for subdivision on upper west Ralston Avenue began in July 1954. Altered sandstone and basalt. Four Northwest 2-yard diesel shovels. Contract for 1,800,000 yards of fill for new Bayshore Highway project; 600 trucks hauling 20,000 yards per day.
	Woodside						See Canada Road.

STONE (DIMENSION)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	Brady, O.E.	Colma (?)					Metamorphosed sandstone. Used in a Crocker Building and Starr King church, San Francisco; pre 1888. (Irelan 88:434).
	Britton Ranch	M.B. Brittan (?)	14,22, 23(?)	5S	4W	MD	Sandstone for railroad depot at San Carlos; pre 1888. (Irelan 88:534).
	Irwin						See under Granite.

SPECIALTY SAND (ASPHALT AGGREGATE)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
36	Duncan		25	5S	5W	MD (proj.)	Beach sand for local use reclaimed from mouth of Frenchman Creek. Inactive.
37	Edgemar	Rockaway Quarry, Inc. Mori Point Road, Rockaway Beach	23	3S	6W	MD (proj.)	Dune quartz sand mined with a Michigan #125 payloader at Edgemar. Sand used in asphalt and concrete mixes.
38	Pacific Coast Aggregates Inc.	Pac. Coast Aggregates, Inc. (Op.) 400 Alabama St., San Francisco	NW¼32	3S	5W	MD (proj.)	Foundations, fill. Active.
39	Pilarcitos		30	5S	5W	MD (proj.)	Beach sands recovered by slack line scraper. Plant dismantled. Operated about 1910-16. (Huguenin and Castello 20:177).
40	Rockaway	Rockaway Quarry, Inc. Mori Point Road, Rockaway Beach	NW¼2	4S	5W	MD (proj.)	Recover beach sand using a slackline cableway, Sauerman 1 yard bucket, and 50 foot gin pole. Sand used in concrete mix, foundations, fill. Intermittent activity.
41	State	State of California	33	7S	5W	MD (proj.)	Dune sand near Pescadero. Small quantities used by State and County for repair of roads, locally.

SPECIALTY SAND (FOUNDRY)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
42	Brumley-Donaldson Co. (Industrial Mineral Products, Inc.)	Brumley Donaldson, operator; 75 Market St., Oakland	23	3S	5W	MD	Quaternary alluvial deposit on weathered surface of Franciscan rocks. Processed for foundry sand. Production discontinued in 1949 owing to competition from synthetic foundry sands. (Senior 29:225,256; Wright 48:61,62; herein).
43	Brumley-Donaldson Co.	Brumley Donaldson, operator; 75 Market St., Oakland	9	4S	5W	MD (proj.)	Oxidized upper portion of Merced formation processed for foundry sand. Production about 1944-49. Mining discontinued owing to competition of synthetic foundry sands. (Wright 48:60,61; herein).

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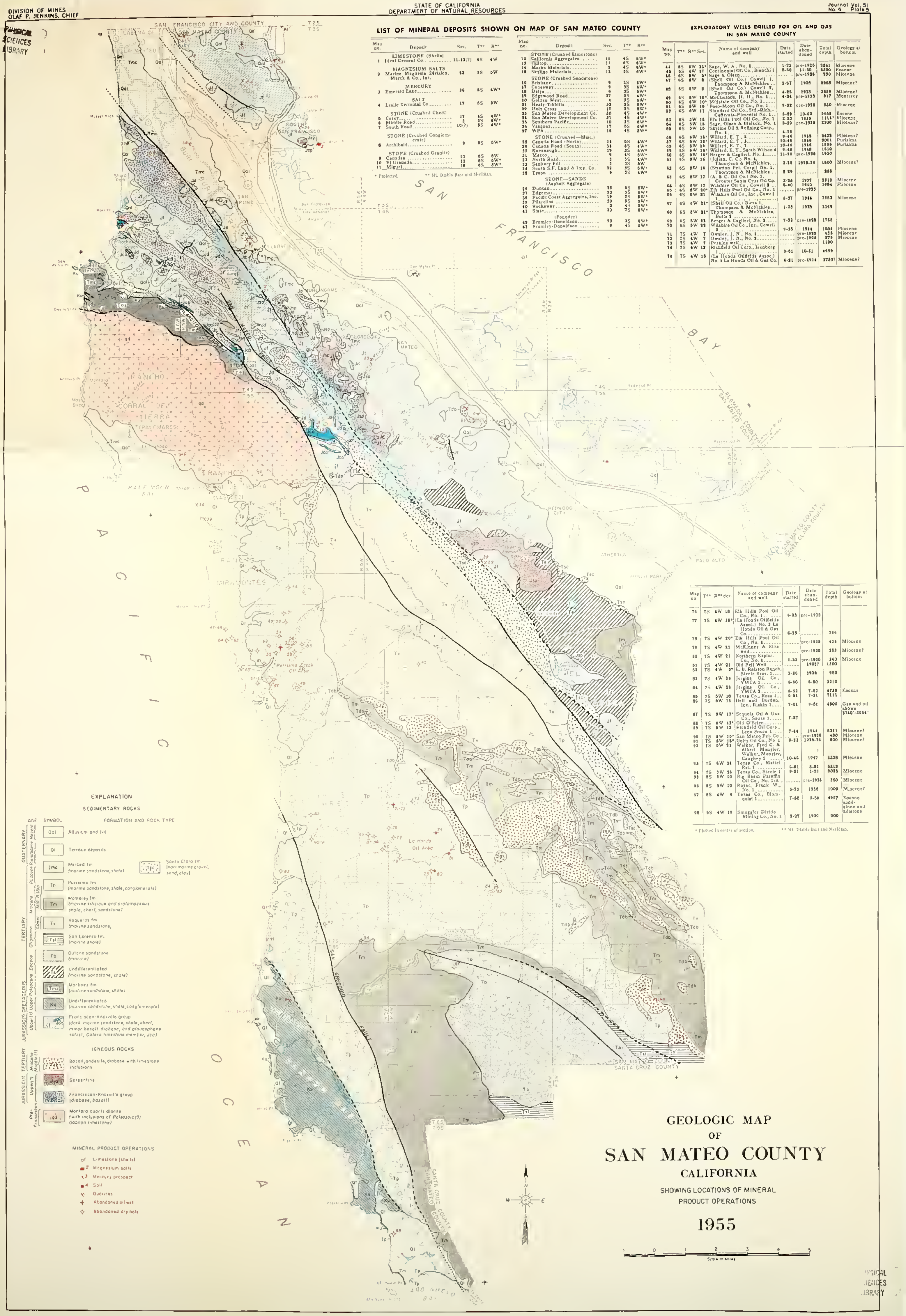
SAN FRANCISCO CITY AND COUNTY
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SANTA CRUZ COUNTY
RANCHO CORRAL DE TIERRA (PALOMARES)
HALF MOON BAY
MIRAMONTES
Purisima Creek Oil Area
La Honda Oil Area
SAN ANDREAS FAULT
PILARCITOS FAULT
SANTA CRUZ FAULT ZONE
SAN GREGORIO FAULT
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PACIFIC OCEAN
T3S
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T5S
EXPLANATION
SEDIMENTARY ROCKS
AGE
SYMBOL
FORMATION AND ROCK TYPE
QUATERNARY
Recent
Pleistocene
Qal
Alluvium and fill
Qt
Terrace deposits
Pliocene
Tmc
Merced fm
(marine sandstone, shale)
Tsc
Santa Clara fm
(non-marine gravel, sand, clay)
TERTIARY
Miocene
Mid & Upp
Lower
Tp
Purisima fm
(marine sandstone, shale, conglomerate)
Tm
Monterey fm
(marine siliceous and diatomaceous shale, chert, sandstone)
Tv
Vaqueros fm
(marine sandstone,
Oligocene
Tsl
San Lorenzo fm
(marine shale)
Eocene
Tb
Butano sandstone
(marine)
Te
Undifferentiated
(marine sandstone, shale)
Paleocene
Tmz
Martinez fm
(marine sandstone, shale)
CRETACEOUS
Upper
Ku
Undifferentiated
(marine sandstone, shale, conglomerate)
JURASSIC(?)
Upper(?)
Jf
Jco
Franciscan-Knoxville group
(dark marine sandstone, shale, chert, minor basalt, diabase, and glaucophane schist, Calera limestone member, Jco)
IGNEOUS ROCKS
TERTIARY
Miocene
Middle (?)
Tdb
Basalt, andesite, diabase with limestone inclusions
JURASSIC(?)
Upper(?)
Serpentine
Franciscan-Knoxville group
(diabase, basalt)
Pre-Franciscan
qd
Montara quartz diorite
(with inclusions of Paleozoic (?) Gabilan limestone)
MINERAL PRODUCT OPERATIONS
Limestone (shells)
Magnesium salts
Mercury prospect
Salt
Quarries
Abandoned oil well
Abandoned dry hole
Scale in Miles
N
S
E
W

GEOLOGIC MAP
OF
SAN MATEO COUNTY
CALIFORNIA
SHOWING LOCATIONS OF MINERAL PRODUCT OPERATIONS
1955

LIST OF MINERAL DEPOSITS SHOWN ON MAP OF SAN MATEO COUNTY

Map no.	Deposit	Sec.	T**	R**
	LIMESTONE (Shells)			
1	Ideal Cement Co.	11-12(?)	4S	4W
	MAGNESIUM SALTS			
2	Marine Magnesia Division, Merck & Co., Inc.	33	3S	5W
	MERCURY			
3	Emerald Lake	36	5S	4W*
	SALT			
4	Leslie Terminal Co.	17	5S	3W
	STONE (Crushed Chert)			
5	Casey	17	4S	4W*
6	Middle Road	3	5S	4W*
7	South Road	10(?)	5S	4W*
	STONE (Crushed Conglomerate)			
8	Archibald	9	8S	5W*
	STONE (Crushed Granite)			
9	Canadas	22	6S	5W
10	El Granada	13	5S	6W*
11	Miguel	18	6S	5W*
	STONE (Crushed Limestone)			
12	California Aggregates	11	4S	6W*
13	Hilltop	31	5S	6W*
14	Marks Materials	2	4S	6W*
15	Skyline Materials	12	5S	5W*
	STONE (Crushed Sandstone)			
16	Brisbane	9	3S	5W*
17	Causeway	9	3S	5W*
18	Dalys	6	3S	5W*
19	Edgewood Road	27	5S	4W*
20	Golden West	4	3S	5W*
21	Healy-Tibbitts	10	3S	5W*
22	Holy Cross	17	3S	5W*
23	San Mateo Development Co.	30	4S	4W*
24	San Mateo Development Co.	31	4S	4W*
25	Southern Pacific	10	3S	5W*
26	Vasquez	17	5S	5W*
27	WPA	16	4S	5W*
	STONE (Crushed—Misc.)			
28	Canada Road (North)	34	5S	4W*
29	Canada Road (South)	34	5S	4W*
30	Kavanaugh	19	3S	6W*
31	Macco	9	4S	5W*
32	North Road	3	5S	4W*
33	Sanitary Fill	3	3S	5W
34	South S.F. Land & Imp. Co.	22	3S	5W*
35	Tyson	9	5S	4W*
	STONE—SANDS (Asphalt Aggregate)			
36	Duncan	35	5S	5W*
37	Edgemar	33	3S	6W*
38	Pacific Coast Aggregates, Inc.	19	3S	5W*
39	Pilarcitos	30	5S	5W*
40	Rockaway	2	4S	5W*
41	State	33	7S	5W*
	(Foundry)			
42	Brumley-Donaldson	13	3S	6W*
43	Brumley-Donaldson	9	4S	5W*

* Projected. ** Mt. Diablo Base and Meridian.

EXPLORATORY WELLS DRILLED FOR OIL AND GAS IN SAN MATEO COUNTY

Map no.	T**	R**	Sec.	Name of company and well	Date started	Date abandoned	Total depth	Geology at bottom
44	6S	5W	33*	Sage, W. A., No. 1	1-22	pre-1926	2643	Miocene
45	6S	4W	17	Continental Oil Co., Bianchi 1	5-50	11-50	5850	Eocene
46	6S	5W	3*	Sage & Olsen	......	pre-1926	930	Miocene
47	6S	5W	8	(Shell Oil Co.) Cowell 1, Thompson & McNichles	3-27	1928	5905	Miocene?
48	6S	5W	8	(Shell Oil Co.) Cowell 2, Thompson & McNichles	4-28	1928	3589	Miocene?
49	6S	5W	10*	McClintock, H. H., No. 1	4-24	pre-1935	517	Monterey
50	6S	5W	10*	Midstate Oil Co., No. 1				
51	6S	5W	10	Poso-Moon Oil Co., No. 1	9-22	pre-1925	530	Miocene
52	6S	6W	11	Standard Oil Co., Std.-Rich.-Cafferata-Pimental No. 1	8-52	10-52	8658	Eocene
53	6S	5W	15	Elk Hills Pool Oil Co., No. 1	2-23	1925	1114?	Miocene
54	6S	5W	15	Sage, Olsen & Blalack, No. 1	5-23	pre-1925	2100	Miocene?
55	6S	5W	16	Skyline Oil & Refining Corp., No. 1	4-28			
56	6S	5W	16*	Willard, E. T., 2	9-46	1945	2422	Pliocene?
57	6S	5W	16*	Willard, E. T., 3	10-46	1946	2001	Purisima
58	6S	5W	16	Willard, E. T., 1	10-44	1946	1896	Purisima
59	6S	5W	16*	Willard, E. T., Sarah Wilson 4	9-48	1948	1610	
60	6S	5W	16*	Berger & Caglieri, No. 1	11-21	pre-1926	1910	
61	6S	5W	16	(Julian, C. C.) No. 4, Thompson & McNichles	1-25	1925-26	1600	Miocene?
62	6S	5W	16	(Stratton Pet. Corp.) No. 1, Thompson & McNichles	8-29	....	286	
63	6S	5W	17	(A. & C. Oil Co.) No. 1, Greater Santa Cruz Oil Co.	3-26	1927	2810	Miocene
64	6S	5W	17	Wilshire Oil Co., Cowell 3	6-40	1940	1984	Pliocene
65	6S	5W	20*	Elk Hills Pool Oil Co., No. 1	......	pre-1925		
66	6S	5W	21	Wilshire Oil Co., Inc., Cowell 1	8-37	1944	7952	Miocene
67	6S	5W	21*	(Shell Oil Co.) Butts 1, Thompson & McNichles	1-25	1928	3367	
68	6S	5W	21*	Thompson & McNichles, Butts 2				
69	6S	5W	22	Berger & Caglieri, No. 2	7-22	pre-1928	1765	
70	6S	5W	22	Wilshire Oil Co., Inc., Cowell 2	9-35	1944	1504	Pliocene
71	7S	4W	7	Owsley, J. N., No. 1	......	pre-1935	638	Miocene
72	7S	4W	7	Owsley, J. N., No. 2	......	pre-1935	375	Miocene
73	7S	4W	7	Perkins well	......	....	1100	
74	7S	4W	12	Richfield Oil Corp., Isenberg 1	9-51	10-51	4499	
75	7S	4W	16	(La Honda Oilfields Assoc.) No. 1 La Honda Oil & Gas Co.	4-21	pre-1924	2740?	Miocene?
76	7S	4W	18	Elk Hills Pool Oil Co., No. 1	6-25	pre-1935		
77	7S	4W	18*	(La Honda Oilfields Assoc.) No. 3 La Honda Oil & Gas Co.	6-25	....	786	
78	7S	4W	20*	Elk Hills Pool Oil Co., No. 2	......	pre-1935	435	Miocene
79	7S	4W	21	McKinney & Ellis well	......	pre-1935	255	Miocene?
80	7S	4W	21	Northern Explor. Co., No. 1	1-23	pre-1926	340	Miocene
81	7S	4W	21	Old Bell Well	......	1905?	1300	
82	7S	4W	5*	E. D. Ralston Ranch, Steele Bros. 1	3-36	1936	980	
83	7S	4W	26	Jergins Oil Co., YMCA 1	6-50	6-50	2010	
84	7S	4W	26	Jergins Oil Co., YMCA 2	6-52	7-52	4735	Eocene
85	7S	5W	10	Texas Co., Ross 1	6-51	7-51	7111	
86	7S	6W	13	Bell and Burden, Inc., Riskin 1	7-51	9-51	4600	Gas and oil shows 3740'-3954'
87	7S	5W	13*	Sequoia Oil & Gas Co., Soura 1	7-27			
88	7S	5W	13*	Old O'Brien				
89	7S	5W	13	Richfield Oil Corp., Leon Soura 1	7-44	1944	6311	Miocene?
90	7S	5W	15*	San Mateo Pet. Co.	......	pre-1926	450	Miocene
91	7S	5W	15*	Unity Oil Co., No. 1	8-23	1925-26	600	Miocene?
92	7S	5W	31	Walker, Fred C. & Albert Mounier, Walker, Mounier, Caughey 1	10-46	1947	3338	Pliocene
93	7S	6W	24	Texas Co., Mattei Est. 1	6-51	8-51	6813	
94	7S	5W	36	Texas Co., Steele 1	9-51	1-52	5075	Miocene
95	8S	3W	10	Big Basin Paraffin Oil Co., No. 1-A	......	pre-1915	360	Miocene
96	8S	3W	10	Royer, Frank W., No. 1	5-33	1935	1000	Miocene?
97	8S	4W	4	Texas Co., Blomquist 1	7-50	9-50	4987	Eocene sandstone and siltstone
98	9S	4W	19	Smuggler Divide Mining Co., No. 1	9-27	1930	900	

* Plotted in center of section. ** Mt. Diablo Base and Meridian.

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